

MOJZA

O Levels & IGCSE

BIOLOGY NOTES

5090 & 0610



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CONTENTS

Pg 02 Unit 1 Cells

Pg 06 Unit 2 Classification

Pg 14 Unit 3 Movement In
and Out of Cells

Pg 16 Unit 4 Biological
Molecules

Pg 17 Unit 5 Enzyme

Pg 19 Unit 6 Plant Nutrition

Pg 22 Unit 7 Transport in
Flowering Plants

Pg 28 Unit 8 Human Nutrition

Pg 38 Unit 9 Human Gas
Exchange

Pg 40 Unit 10 Respiration

Pg 42 Unit 11 Transport in
Humans

Pg 49 Unit 12 Disease and
Immunity

Pg 58 Unit 13 Excretion

Pg 60 Unit 14 Coordination
and Control in Humans

Pg 68 Unit 15 Coordination
and Control in Plants

Pg 70 Unit 16 Development of
organisms and continuity of
life

Pg 85 Unit 17 Inheritance

Pg 89 Unit 18 Biotechnology
and Genetic Modification

Pg 92 Unit 19 Relationships of
organisms with one another
and with the environment
(Ecology)

Pg 97 Practical Work

Unit 1: Cells

Cell Structure and Function

- Staining

- Cells are soaked in chemicals/dyes before being examined under a microscope, so that certain organelles take up the dye, making the cells more visible.
- Common stains are:
 - ↳ Methylene blue for animal cells
 - ↳ Iodine solution for plant cells

- Functions of different structures cells:

Structure	Description	Location	Function
Cell Surface Membrane	Partially permeable layer enclosing the cell made of lipids and proteins Not found in Virus cell	Surrounding the cytoplasm	→ Prevents cell's contents from escaping → Controls the movement of substances into and out of the cell
Cytoplasm	Jelly-like substance containing organelles and food granules	Surrounded by the cell membrane and fills the entire cell	→ Most chemical reactions take place here → Contains the organelles, which are embedded in it → Contain enzymes, salts and food reserves such as lipids
Nucleus	Circular or oval, double membrane-bounded structure	Present in the cytoplasm	→ Nucleus controls: ↳ Cell activities ↳ Cell division (contains hereditary material) ↳ Cell development
Mitochondria	Small spherical or rod-shaped structure	Present in cytoplasm	→ Site of cellular/aerobic respiration → Release energy to sustain metabolic reactions and cellular activities
Ribosomes	Small circular structures; membraneless	Present in the cytoplasm, either attached to membranes or lying free	→ Proteins' synthesis

Cell wall	Fully permeable, rigid, non-living layer made of cellulose in plants. Extra: Made up of peptidoglycan in bacteria, chitin in fungi and cellulose in plant cells	First outer layer, enclosing the cell membrane	→ Lets water, salts and other substances move through it freely → Gives cells rigidity and structure, while protecting them from bursting
Vacuole	Large, permanent membrane-bound structure in plant cells, while temporary in animal cells	Inside the cytoplasm	→ Provides turgidity to plant cells → Contains water, salts and sugar → Used as a disposal site for by-products
Chloroplast	Round, oval or disk-shaped structure, containing pigment called chlorophyll	Inside the cytoplasm	→ Site of photosynthesis → Traps light energy for photosynthesis
Circular DNA	Single, coiled, circular chromosome	Inside the cytoplasm	→ Controls: ↳ Cell division ↳ Cell growth ↳ Cell activities
Plasmids	Circular pieces of DNA	Inside the cytoplasm	→ Contain extra genes than those in the circular DNA to aid in the processes of reproduction and survival

KEY:

Only plant cells

Only animal cells

Only bacterial cells

Both plant and animal cells

Both plant and bacterial cells

All three cells

- Specialised Cells

- Specialised cells have specific functions
- Their structures are specialised and specific, to help them in their function.
- Examples:
 - ↳ ciliated cells – movement of mucus in the trachea and bronchi away from lungs
 - ↳ root hair cells – absorption of ions and water
 - ↳ palisade mesophyll cells – photosynthesis
 - ↳ neurones – conduction of electrical impulses
 - ↳ red blood cells – transport of oxygen
 - ↳ sperm and egg cells (gametes) – fertilisation and hence reproduction

- Examples of specialised cells according to 2023-2025 syllabus:

- Red Blood Cell

Function:

- Contains a red pigment - haemoglobin - which enables the cell to transport oxygen from the lungs to all parts of the body.

Adaptive Features:

- Bi concave → Increases surface area to volume ratio; as a result, O₂ can diffuse in and out of the cell quicker
- Flexible and elastic → So they can squeeze into the capillaries

- Root Hair Cells

Function:

- Absorb water through osmosis and uptake mineral salts from the soil through active transport

Adaptive Features:

- Long and narrow root hair/cytoplasmic extension → Increases surface area to volume ratio of the cell for more efficient absorption
- **Mitochondria:** Many mitochondria are present to provide energy for active transport
- **Concentrated sap vacuole:** Creates a water potential gradient for entry of water into the cell

Definitions:

- Cells:

- All organisms are made of cells.
- Cells are fundamental units of life which can survive independently and carry out necessary functions for survival.
- All cells originate from pre-existing cells.
- Examples: root hair cell, palisade mesophyll cell, ciliated cell, red blood cell, sperm cell, egg cell, etc.

- Tissue:

- A group of cells with similar structures working together to perform a shared, specialised function.
- Examples: blood - group of blood cells; mesophyll layer - group of spongy and palisade mesophyll cells, etc.

- Organ:

- Structure made up of a group of tissues working together to perform a specific function.
- Examples: Heart - group of muscle tissues; Leaf - group of mesophyll tissues, vascular tissues, etc.

- Organ systems:

- Group of organs with related functions working together to perform a bodily function.
- Examples: Cardiovascular system - group of organs such as blood vessels and heart, etc; Shoot system - group of organs such as stem, leaves, etc.

- Organism:

- An individual animal or plant, formed by all the organs and systems working together to produce an independent living thing.

Size of Specimens:

- **Magnification = image size/actual size**
- Conversion of units:
 - ↳ 1000000 micrometres = 1 metre
 - ↳ 10000 micrometres = 1 centimetre
 - ↳ 1000 micrometres = 1 millimetre

Unit 2: Classification

- Classification means arranging the organisms in groups and sub-groups based on their similarities and differences
- Species are the group of closely related organisms that can reproduce fertile offspring freely in nature
- **Dichotomous key** is a commonly used tool for classification, which helps in identifying unknown organisms (Mostly MCQs will be related to this)
Used to:
 - ↳ Identify unfamiliar organisms
 - ↳ Simplify the process of identification
 - ↳ Separating species by contrasting features

System of Classification

- All the living organisms are classified into domains; the two domains are Domain Prokaryotes and Domain Eukaryotes
- Living organisms are then divided according to the Kingdom
- Examples: Kingdom Animalia, Kingdom Plantae; we have 5 major kingdoms which are included in our syllabus.
- Viruses are at the boundary of living and nonliving organisms and hence, aren't a part of the 5 kingdoms
- Within each kingdom, the organisms are further divided into several phyla (Singular: Phylum); this is equivalent to division, which we use in the case of plants
- Each phylum consists of organisms which differentiate them with other kingdoms. The organisms of one phyla share similar characteristics, but they might not be obvious, forming one of the main categories in biological classification that ranks above the class and below the kingdom
- The phylum is made up of classes; organisms of a class further share more common attributes
- Class ranks below the phylum and above the order
- Classes are divided into orders; the orders further divide organisms into more specialised groups which have more qualities in common. Order ranks above family and below class
- Within each order are the families. In the family, the name suggests the species' resemblance is fairly close
- For animals, the family usually ends with idae; meanwhile, in plants it ends with aceae. Family ranks below order and above genus
- Each family consists of a varying number of genera (Singular: Genus). Each genera divides species into having similar structural characteristics, but the species are not as closely related
- Lastly, genera divides into species; each genus has several species
- Binomial nomenclature means 'two-term naming system'; it comprises of genus and species and is often written in italics
E.g. *Canis* (Genus) *familiaris* (specie)

Modes of nutrition

- There are 2 modes of nutrition, and they are:
 - ↳ **Autotrophic nutrition:** In which organisms make their own food; such organisms are called autotrophs, which includes Plants and some bacteria
 - ↳ **Heterotrophic nutrition:** In which the organisms feed on readily available food materials; such organisms are called heterotrophs

- Animals and their kingdoms

- There are further two types in the animal kingdom:
 - ↳ Vertebrates: animals with a backbone
 - ↳ Invertebrates: animals without a backbone

Invertebrate Groups

- Arthropods

- Arthropods are invertebrate animals that have an exoskeleton, a segmented body and jointed appendages as their main features
- The "Phylum" arthropoda is subdivided into 4 classes:
 - ↳ Insects
 - ↳ Arachnids
 - ↳ Myriapods
 - ↳ Crustaceans
- Characteristics of all arthropods:
 - ↳ Exoskeletons made of chitin
 - ↳ Highly developed sense organs
 - ↳ Jointed limbs
 - ↳ Segmented bodies
 - ↳ Ventral nervous system
 - ↳ Bilateral symmetry, which is the same externally and internally

Key terms:

- Appendages : refer to any of the homologous body parts that may extend from a body segment, including antennae,wings etc.
- Ventral : Underside; along the stomach

Insecta	→ 3 pairs of legs (Total 6) → 3 segments of the body (Head, thorax and abdomen) → 1 pair of antennae → Usually have 2 pairs of wings	→ Have compound eyes which produce several images on the retinula cells → This forms a complex image, due to which the insects are able to detect even the slightest of movements	→ Examples: Ants, Wasps, Butterflies
Arachnida	→ 4 pairs of legs and have 2 pairs of appendages near the mouth: Chelicerae and Pedipalps (Total 10 appendages). → 2 segments of the body, which are the cephalothorax (head and thorax fused together) and abdomen → No antennae or wings → Several pairs of simple eyes	→ Mostly carnivorous and feed on insects and other small animals → Some arachnids are venomous, who inject venom in their prey to paralyse it → Arachnids usually lay eggs, which hatch into immature arachnids that are similar to adults. Scorpions, however, give birth to live young → Chelicerae are tipped with fangs for feeding, while pedipalps are sensing or mating.	→ Examples: Spiders, Scorpions
Myriapoda	→ Many joined limbs → They have a head and the body is elongated with numerous segments, therefore, it does not divide into a thorax or abdomen → There is at least 1 pair of legs on each segment → Simple eyes → They have a pair of antennae	→ Breathe through series of small openings known as spiracles → Most abundant and diverse in tropical and temperate forests	→ Examples: Centipedes, Millipedes
Crustaceans	→ 2 pairs of antennae → The head is fused with the thorax region to form a cephalothorax, and an abdomen is also present. Therefore, it has two segments of the body → Compound eyes → 5 or more pairs of limbs	→ Exclusively aquatic → Gills for breathing → Front limbs are modified into chelipeds, which help in holding and biting, as well as catching the prey → Hard covering of the exoskeleton	→ Examples: Crabs, Lobsters, Shrimps

Phylum Cordata/Vertebrates

→ The "Phylum" Cordata is sub-divided into 5 classes:

- ↳ Fishes
- ↳ Amphibians
- ↳ Reptiles
- ↳ Birds
- ↳ Mammals

→ **Common features of Phylum Cordata animals:**

- ↳ All the animals except tunicates are vertebrates
- ↳ They have separate openings for the mouth and the anus
- ↳ Vertebrates do not have an exoskeleton, but they have an internal skeleton
- ↳ Animals are heterotrophs (Feed on other organisms for nutrition)

Features	Fishes	Amphibians	Reptiles	Mammals	Birds
Skin	→ Scally, lose wet scales	→ Thin, moist and slimy	→ Dry, hard and scaly	→ Hair/fur on their body	→ Scales on legs, and body covered with feathers
Reproduction	→ External Fertilisation takes places when male shed sperm on the eggs laid by females → Sexual reproduction as two parents involves	→ External fertilisation takes place, when male amphibians shed sperm on eggs → Sexual reproduction	→ Eggs are internally fertilised, when the reptiles mate. Females can lay the eggs, or keep it until the time for hatching → Sexual reproduction	→ Sexual Reproduction between male and female	→ Internal fertilisation, when birds mate → Sexual reproduction
Eggs	→ Soft jelly-like shell in water	→ Do not have a soft skin, not a hard shell	→ Thick, leathery or rubbery shells, which are waterproof → Laid on land	→ Sperm and Ovum fertilised together to make embryo → Embryo turns into foetus and then a baby (Pregnancy)	→ Hard, calcareous shells → Laid on land, in the nests, where mother will incubate them
Sensitivity	→ Lateral lines along their body to detect and respond to vibrations	→ Sensory organs such as eyes and ears are present → Do not have a	→ Eyes and ears to sense → Do not have a pinna	→ Sense organs such as eyes, ears and nose are present → External flap of	→ Eyes and ears present → Pinna is absent

		pinna		ear known as pinna is also present Have ears with 3 bones: Malleus, incus and stapes	
Locomotion / Mobility	→ Fins → Stream-line body → Helps to swim underwater, while maintaining balance	→ Some amphibians such as frogs and toads have 4 limbs → Their hind feet have webbed toes, which provides a large surface area for efficient swimming	→ 4 limbs, which each having 5 toes → Snakes don't have any limbs	→ 4 limbs are present	→ 2 Wings and 2 Feet
Breathing	→ Use gills	→ They can live on land and water both, hence may have lungs and gills both; however, diaphragm is absent → Amphibians perform gas exchange through their skin, which is thin, moist and has good supply of blood	→ Lungs	→ Lungs	→ Lungs
Blood Temp.	Cold-Blooded	Cold-Blooded	Cold-Blooded	Warm-Blooded	Warm-Blooded
Food	→ Diet consist of eggs, algae, plants, crustaceans, worms, mollusks, insects, insect larvae, amphibians, and plankton	→ Adults amphibians are carnivores which feed on insects → Young ones, such as, tadpoles, are herbivores and feed on algae	→ Mostly carnivores → Feed on insects, amphibians and can feed on other reptiles	→ Carnivores, Herbivores or Omnivores → Have 4 types of teeth: incisors, canines, premolars and molars to chew the food	→ Omnivores → Have beak to feed on variety of things
Other	→ Transparent	→ Nictitating	→ Have nictitating	→ Have special	→ Have

features	eyelids to prevent water entering and allowing focus	membrane to protect the eyes	membrane, to protect the eyes	mammary glands to breastfeed their young ones	lightweight bones, which help in flying →Wings also help in flying
Examples	Shark, Tuna, Rahu, Trout	Frogs, Toads, Newts, Salamanders	Snakes, lizards and crocodiles	Humans, cats and bears	Chicken, hummingbird

Plants

→ Kingdom Plantae plants are the multicellular organisms which belong to the Domain Eukaryote; therefore, they have a nucleus and membrane bound organelles

- ↳ Plants are the organisms that use chlorophyll to carry out photosynthesis
- ↳ There are two main divisions of plants: ferns and flowering plants
- ↳ Flowering plants have further two types: monocots and dicots

- Ferns:

- Ferns, also known as filicinophytes are the plants that do not have flowers; therefore, they do not reproduce by pollination. Ferns do not produce:
 - ↳ Flowers
 - ↳ Fruits
 - ↳ Seeds
 - ↳ Ovules (female gamete)
 - ↳ Pollen (male gamete) Cambium tissue is also absent in ferns
- Flowering plants reproduce sexually by pollination, (which we will study in a later Unit) while ferns reproduce in a way similar to fungi
- This asexual way of reproduction is known as spore formation. The leaves of ferns are known as fronds. At the underside of fronds, sporangia can be found
- When sporangia are mature, they burst and the spores are released; they are carried by the wind and rain to far away areas. The spores find moist soil, germinate and then grow.

- Flowering plants:

- Also known as angiospermophytes can be classified into:
 - ↳ Dicotyledons
 - ↳ Monocotyledons
- In flowering plants, roots, stems, and leaves are present
- Cambium tissue is also present

- Reproduction in flowering plants/angiospermophytes:

- Flowering plants reproduce by pollination
- This process of sexual reproduction involves two gametes: pollen and ovule
- The pollen is released from the anthers of flowers, and is carried by the wind or insects to the stigma of the flower
- The pollen grains secrete special hydrolysis enzymes on the stigma and digest its wall to make its way to the ovary
- The male nucleus from the pollen then travels through this pollen tube and enters the ovary through the microphile. The male nucleus will fuse with the ovule (female nucleus), and fertilisation will occur
- After fertilisation, the ovule develops into a seed and the ovary develops into a fruit. The dispersal of seeds by wind/water/animals will allow the seeds to find a place for germination and grow into a plant

Dicotyledons and Monocotyledons

Dicots	Monocots
Two cotyledons present in their seeds	One cotyledon present in their seeds
Broad leaves, with network of veins	Elongated leaves, with parallel veins
Petals in multiples of 4 or 5	Petals in multiples of 3
Tap roots	Fibrous roots
Ringed vascular bundle	Scattered vascular bundle

Viruses

- They are at the boundary of living and non-living things
- Viruses have the following characteristics:
 - ↳ Live as parasites in the hosts' body
 - ↳ Strictly parasitic
 - ↳ Take food and shelter in the hosts' body, and give diseases in return
 - ↳ Have no organelles, cytoplasm, etc.
 - ↳ Acellular
 - ↳ Reproduce inside the hosts' body
 - ↳ Cannot survive outside (die outside)
 - ↳ Crystallise outside hosts
 - ↳ Different shapes
- Viruses are made up of:
 - ↳ A nucleic acid (Either RNA or DNA)

- ↳ Protein coat, known as capsid
- ↳ No protoplasm and, therefore, are non-cellular
- Viruses are made up of a nucleic acid, which can be RNA or DNA (genetic material), which is surrounded by a protein coat known as a capsid
- In cellular cells, DNA is always double strand, and RNA is single strand. Since viruses are not cellular structures, they can have single strand DNA and double strand RNA as well; therefore, viruses can have 4 types of nucleic acids
 1. Single strand DNA
 2. Double strand DNA
 3. Single strand RNA
 4. Double strand RNA
- Viruses cause various diseases such as:
 - ↳ AIDS (Acquired Immunodeficiency Syndrome)
 - ↳ Ebola
 - ↳ Influenza
 - ↳ SARS (Severe Acute Respiratory Syndrome)
 - ↳ Smallpox
 - ↳ Chicken Pox
 - ↳ Herpes
- Antibiotics cannot be used to treat viral infections, and viruses can only be destroyed by antibodies produced by white blood cells. However, doctors might prescribe antibiotics when you have a viral infection as a precautionary/deterrent measure.
- This protects your body from acquiring a possible bacterial infection which it would normally be able to fight against, but not currently, as your resistance is very low during this time.

Unit 3: Movement In And Out Of The Cell

Roles of Water:

- **Digestion:** water is required for the hydrolysis of food molecules, alongside being a major component of digestive juices
- **Excretion:** water is the solvent for the removal and dilution of toxic excretory substances
- **Transport:** water is the main solvent, acting as the transport medium by being an essential constituent of blood plasma

Diffusion:

- The net movement of molecules or ions from a region of their higher concentration to a region of their lower concentration (i.e. down the concentration gradient), as a result of their random movement.
- Both solute and solvent move.
- The energy for diffusion comes from the kinetic energy of random movement of molecules or ions.

- Factors affecting the rate of diffusion:

Surface Area	The greater the surface area between the areas of the different concentrations, the greater the rate of diffusion, as more particles can diffuse across the surface in the same time period when compared to a lesser surface area.
Temperature	The greater the temperature of the molecules, the greater the rate of diffusion, as the particles have more kinetic energy and hence a greater speed.
Concentration Gradient	Concentration gradient is the difference in concentrations of a substance between two areas. The steeper the concentration gradient between the areas of different concentrations, the greater the rate of diffusion
Distance	The greater the distance between the areas of different concentrations, the lesser the rate of diffusion, as the particles have to travel more distance in the same time period as compared to a lesser distance.

Osmosis:

- The net movement of water molecules from a region of higher water potential to a region of lower water potential (i.e. down the water potential gradient), through a partially permeable membrane
- Only solvent moves
- **Water potential:** the potential energy of water to move from one place to another
- A water potential gradient is required for the uptake and loss of water via osmosis
- Placing an animal cell in a high water potential solution will lead to the osmosis of water into it, causing the cell to increase in size and burst, as it does not have a rigid cell wall to withstand the pressure.
- Placing a plant cell in a high water potential solution will lead to the osmosis of water into it, causing the cell to become turgid; it won't burst, as the cell wall exerts an opposing pressure to further entry of water.
- Placing an animal cell in a low water potential solution will lead to the osmosis of water out of it, causing the cell to undergo crenation i.e. shrinkage and formation of ruffled and crescent-shaped edges. As water is lost from it and can lead to the dehydration and cell's death
- Placing a plant in a low water potential solution will lead to the osmosis of water out of it, causing it to undergo plasmolysis
- **Turgid:** the state of a cell being swollen and hard due to high turgor pressure
- **Turgor pressure:** the force caused by water within a cell that presses the cell membrane outwards against the cell wall - this is what supports plant cells and keeps them erect and upright
- **Plasmolysis:** the process of shrinkage of the protoplasm of a plant cell away from the cell wall due to the loss of water in a cell
- **Flaccid:** the state of a cell lacking turgidity and being soft and floppy

Active Transport:

- the movement of molecules or ions into or out of a cell through the cell membrane, from a region of their lower concentration to a region of their higher concentration (i.e. against the concentration gradient), using energy released during respiration.
- Active transport requires energy because molecules or ions move against the direction they would naturally move towards
- Importance of active transport in root hair cells: Active transport takes place in root hair cells where it enables ions to be taken up by the root hair cells even if the ions' concentration in the soil falls below the ions concentration in the root hair cells, in which case the ions would have moved out of the root hair cells by diffusion.

Unit 4: Biological Molecules

Molecules:

Molecule	Elements	Monomers	Examples	Key
Carbohydrates	C, H, O	Glucose	Starch Cellulose Glycogen	C = Carbon H = Hydrogen O = Oxygen N = Nitrogen P = Phosphorus (S) = Sometimes Sulfur
Lipids (fats and oils)	C, H, O	Fatty acids + Glycerol	Oils and Fats: Olive oil Butter Cod liver oil	
Proteins	C, H, O, N, (S)	Amino acids	Enzymes Hormones Carrier Proteins Cell Membranes	
DNA	C, H, O, N, P, (S)	Nucleotides	-----	

Food Tests:

Sample	Test	Method	Positive Result	Negative Result
Starch	Iodine solution	Add a few drops of reagent to sample, on a white tile.	Turns blue-black	Remains orange-brown
Reducing sugar	Benedict's solution	Add equal volumes of the sample and reagent in a boiling tube. Heat it in a water bath to anywhere between 60-100°C.	Turns cloudy green, yellow, orange, or brick-red (Order of increasing positivity)	Remains blue
Protein	Biuret solution	Add a few drops of the reagent to the sample in a boiling tube.	Turns lilac	Remains blue
Lipids	Ethanol emulsion	Dissolve a few drops of the sample in 5 cm ³ of ethanol. Pour this solution into a boiling tube of water.	Milky-white emulsion formed	Remains a clear solution

Unit 5: Enzymes

Definitions

- Catalyst:

a substance that increases the rate of a chemical reaction and is not chemically changed by the reaction

- Enzymes:

proteins that function as biological catalysts and are involved in all chemical reactions

- Substrate:

the substance on which an enzyme acts

- Active site:

a groove on the surface of the enzyme, where the substrate binds and chemical reactions take place

- Enzyme-substrate complex:

a temporary molecule formed when a substrate binds with the enzyme

- Product:

the molecule formed at the end of the reaction that separates from the enzyme

Enzyme action:

- Substrate binds with the enzyme at the active site to form an enzyme-substrate complex.
- Reactions take place at the active site to form the product, which separates from the enzyme, letting it catalyse another reaction.

- Enzyme specificity:

- Enzymes are specific in nature, which catalyse only specific types of chemical reactions.
- Every **enzyme** represents a **lock** which has a **specific substrate** complementary to it, which is its **key**.
- The active site has a specific 3D structure, complementary to a specific substrate; only that specific substrate can bind with the active site to form an **enzyme-substrate complex**.
- So, the enzyme can only catalyse that reaction. This is known as “Lock and key hypothesis”

- Effect of temperature and pH changes on enzyme activity

- Rate of reaction can be found out by measuring the concentrations of substrates and products; the rate of decrease of substrate or rate of increase of products
- Enzymes, being proteins, are sensitive to temperature and pH changes

- Temperature

- Increasing the temperature increases the rate of reaction, up to a certain point
- Increasing the temperature increases the kinetic energy of the molecules
- More collisions occur between the enzyme and the substrate
- The frequency of effective collisions increases
- The optimum temperature of an enzyme is the temperature at which the enzyme shows the maximum rate of activity
- Beyond the optimum temperature, the enzyme starts to get denatured
- Denaturation is the destruction of the 3-dimensional structure of an enzyme
- The active site is permanently destroyed; thus, no enzyme-substrate complex can be formed
- The enzyme can no longer catalyse a reaction, and enzyme activity drops

- pH

- The optimum pH of an enzyme is the pH level at which the enzyme shows maximum activity
- Extreme pH changes decrease enzyme activity, exactly like temperature changes described above

Unit 6: Plant Nutrition:

Photosynthesis:

→ *Photo* means **light**; *synthesis* means **to produce**; therefore, **photosynthesis** is a process by which **green plants** make their own food, i.e. **carbohydrates** in the form of **glucose** from raw materials, which are **carbon dioxide** and **water**, by converting **light energy** into **chemical energy**.

→ Photosynthesis is **photoautotrophic nutrition**.

- Chlorophyll:

- Photosynthesis is a reaction which requires light energy.
- Chlorophyll absorbs light energy and ensures that photosynthesis takes place (Since photosynthesis is a photoautotrophic nutrition, light energy along raw materials is important for the reaction to take place)
- Chlorophyll is present in the chloroplasts of the photosynthesising cells
- Chlorophyll is a **green pigment**, responsible for the green colour of plants
- The light energy absorbed by chlorophyll is transferred to chemical energy (glucose)

- Balanced Equation

- 6 moles of carbon dioxide react with 6 moles of water in the presence of light energy absorbed by chlorophyll. It converts the light energy into chemical energy in the form of glucose, and 6 moles of oxygen are the byproduct
- $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$

- Use And Storage Of Glucose Produced From Photosynthesis

- Glucose is a **monosaccharide** and when many molecules of glucose combined together, they form long-chain **polysaccharides**
- Glucose is converted into **starch** which is stored in cells as an **energy store**; this means that when needed, starch molecules break down into glucose to provide **chemical energy** for cellular respiration
- Glucose is also converted into **cellulose**, which is used to make the **cell wall** of the plant cell
- Glucose is also used in the process of cellular respiration to release energy (ATP)
- Glucose is converted into **sucrose** for transport around the plant known as **Translocation**
- Glucose is also used to secrete **nectar** in **insect-pollinated flowers** to attract insects for **pollination**
- Glucose combines with other **minerals** absorbed from roots to form **lipids** and **amino acids**

- Variegated Leaf

- A variegated leaf is a leaf whose lamina has some green parts which contain chlorophyll, therefore, they can photosynthesise
- Some parts of a variegated leaf's lamina do not contain the green pigment, due to which they do not photosynthesise
- As no photosynthesis occurs, they give negative results for the starch test (Iodine test), because no glucose is produced to be converted into starch
- Chlorophyll containing areas will turn blue-black while areas with no chlorophyll will be brown or changed.

Limiting Factors

- **Limiting factor** is the factor that **directly affects** the **rate of the reaction** if its **quantity** is changed
- **Photosynthesis** is a reaction which results in a series of enzymes. We can say that photosynthesis is an **enzyme-controlled** reaction; therefore, enzymes need the **optimum temperature** to work at their full potential. *(A higher temperature means more kinetic energy, and the frequency of effective collisions increases)*
- If the temperature is altered, the rate of reaction may be affected
- We also know that carbon dioxide is necessary for photosynthesis.
- 6 moles of CO_2 react with 6 moles of H_2O to produce one mole of glucose ($\text{C}_6\text{H}_{12}\text{O}_6$)
- If the concentration of CO_2 is altered, the rate of reaction may be affected
- Light intensity is also important for photosynthesis
- If light intensity is increased or decreased, the rate of reaction may be affected

Limiting factor	Effect
Varying temperature	→ Photosynthesis is an enzyme-controlled reaction, where enzymes such as rubisco are involved in a series of chemical reactions that enable photosynthesis to take place → Enzymes are proteins in nature and their rate of reaction increases as the temperature increases, until the optimum temperature is reached, after which the enzyme denatures → Optimum temperature is the temperature at which enzymatic activity is at its highest
Varying light intensity	→ Light energy is transferred into chemical energy in the form of glucose during the process of photosynthesis → Increasing light intensity will increase the rate of reaction, until another factor like the concentration of CO_2 or temperature becomes limiting → Light is also important to start the process of photosynthesis, as it accounts for opening of stomata for gas exchange.

Varying carbon dioxide concentration	→ Carbon dioxide is reduced by hydrogen to form glucose during photosynthesis → Increasing the concentration of carbon dioxide will increase the rate of reaction, until another factor like the temperature or intensity of light becomes limiting.
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Mineral Nutrition

Mineral	Importance	Deficiency
Magnesium ions Mg^{+2}	- Reacts with glucose molecules to synthesise amino acids for production of proteins - Also required for synthesis of chlorophyll	- Stunted and weak growth - Reduced yield - Chlorosis
Nitrate ions NO_3^-	- Synthesis of chlorophyll, needed for photosynthesis	- Chlorosis: leaves become pale and yellow; yellowing between the veins of leaves

Unit 7: Transport In Flowering Plants

- The hypothesis that explains the mechanisms which control the opening and closing of the guard cells
- During the daytime, the energy from the sunlight is used by the guard cells to transfer the light energy into chemical energy via photosynthesis
- This chemical energy is then used to pump the sodium - potassium ions from the neighbouring epidermal cells inside the guard cells
- This reduces the water potential inside the guard cells
- The reduced water potential inside the guard cell causes them to become more turgid
- The increased turgidity of the guard cells causes them to stretch towards the outside, and hence causes the opening of the stomata
- During the night time, the accumulated potassium ions that were inside the guard cells now diffuse out of them
- This increases the water potential on the inside of the guard cell
- Water then leaves the guard cells through osmosis
- This causes the guard cells to become flaccid and thus, the opening of the stomata closes

- Diagram of stomata in the day and night

Note: To be added

- The movement of carbon dioxide into via the stomata

- During the day, carbon dioxide is consumed inside leaves, leading to a lower concentration of carbon dioxide within them
- A concentration gradient is created, with a higher concentration of carbon dioxide outside the leaf
- Carbon dioxide moves into the leaf through the stomata via diffusion and dissolves in the moist surface of the mesophyll cells to facilitate efficient diffusion

- The functions of xylem in the leaf

- The xylem is responsible for the transportation of water and dissolved mineral ions to the leaves from the roots
- Veins in a leaf form a network and contain xylem and phloem to create a vascular bundle, which extends to the mesophylls. The contents of the vascular bundle exit the vein when necessary, and then move from cell to cell towards mesophyll cells where photosynthesis occurs

- The structure of the transport system in flowering plants

- Plants have a series of vessels present that are responsible for the movement of water and other dissolved substances. These vessels are called transport / vascular tissues, which is composed of two types of tissues:
 - ↳ Xylem
 - ↳ Phloem

Xylem

- It is responsible for the transport of the water and other dissolved minerals from the roots to the stem and the leaves
- It is also responsible for providing mechanical support for the plant.
- Xylem is mainly composed of xylem vessels
- The xylem vessels are long, hollow tubes that stretch from the roots till the leaves
- The xylem vessels are composed of many dead cells
- The inner walls of the xylem vessels are further strengthened by deposits of a waterproof substance called lignin

- Adaptations of xylem vessels

- The lumen is empty, as there is no protoplasm present; furthermore, the cells are joined end-to-end with no cross walls, forming a continuous pathway for water. This helps in providing a smoother flow of water and dissolved ions with little resistance
- The presence of lignin helps thicken the walls of the xylem vessels and provides mechanical support to the vessel, allowing conduction of water without it collapsing

Phloem

- The phloem is responsible for transporting manufactured substances such as sucrose and amino acids from the leaves to the other parts of the plants
- This transportation of prepared food is known as translocation, which is from source to the sink
- During summers, when abundant photosynthesis is taking place, excess carbohydrates and amino acids are translocated from leaves to storage organs such as roots. Here leaves become source of food and roots are sink where food is stored
- During winters, when photosynthesis rate is lower, stored food from roots is translocated to other parts of plants; hence roots become source now
- Translocation can occur in both directions, unlike xylem where water is conducted in one direction only.

- Adaptations of a phloem

- Phloem is composed of companion cells, too, that are responsible for providing energy to sieve tubes to load photosynthesis from the mesophyll cells by active transport.
- There are holes present in sieve plates which allow for rapid movement of the food substances into the sieve tube cells

The arrangement of the Vascular system

- In the stem

- In the dicotyledonous stem, the xylem and the phloem are grouped together to form a vascular bundle
- The vascular bundles are arranged in a ring around the central region called the pith
- The phloem always faces towards the outside, while the xylem faces towards the inside
- Present between the xylem and the phloem is tissue called cambium
- The region between the pith and the epidermis is called the cortex
- The outermost region of the stem is covered by the epidermis. This epidermis is composed of a waxy, waterproof region called the cuticle

- In the roots

- In the dicotyledonous root, the xylem and the phloem are not bundled; instead, they are in an alternating arrangement
The cortex of the root is also a storage tissue
- Present on the epidermis of the root are root hair cells, which together are the outermost layer of the cells. This layer is also called piliferous layer

Entry of water into the plant

- Each root hair cell is a tubular extension of the epidermal cell and is elongated enough to come into close contact with the solution that is surrounding the soil
- The solution that is present in the soil in close contact with the root hair cell is a dilute solution of mineral salts
- There is a sap of high concentration present inside the root hair cell, and this causes water potential inside the root hair cell to become low
- The water then moves into the root hair cell from the soil through osmosis
- This causes the water potential inside the root hair cell to decrease and is then passed on to the cell next to it until the water reaches up the plant

- The absorption of ions and minerals by root hair cells

- The absorption of ions and minerals by the root hair cells can vary accordingly, depending on the condition of the concentration of the soil
- If the concentration of mineral ions is high in the sap of the root hair cell, active transport would take place to move the ions and minerals from the soil. The energy for this active transport comes from the cellular respiration taking place in the root hair cell
- If the concentration of mineral ions is higher in the soil than the root hair cell, then diffusion would take place

- Adaptations of the root hair cells

- The root hair cell is thin and long, which increases the surface area to volume ratio of the cell, making it more efficient at water absorption: uptake of mineral ions
- The root hair cell has a sap that is surrounded by the cell surface membrane, which helps to prevent its contents from leaking. The cell sap serves an important role in maintaining the osmotic potential
- The root hair cell has many mitochondria present to provide energy for the active transport

Root pressure

- The living cells that surround the xylem vessel actively pump ions into the vessels
- This reduces the water potential inside the vessels
- Water then moves into the vessels from the living cells that surround the vessels by osmosis
- This process is called root pressure
- However, it's worth noting that this process alone is not sufficient to move water up into leaves in case of tall trees

Capillary action

- When in very narrow tubes, water tends to move up due to the interactions between water molecules
- This effect is called capillary action
- This is made possible in the case of xylem vessels because the vessels are considered as narrow tubes too

- Cohesion

- The force of attraction between water molecules is called cohesion

- Adhesion

- The force of attraction between water molecules and the inner surface of the xylem vessels is called adhesion

Transpiration

- The loss of water from the plant in the form of water vapour.
- Water evaporates from the surfaces of mesophyll cells into the air spaces, and then diffuses out of the leaves through stomata in the form of water vapours.

- The role of transpiration in the plant

- Transpiration is a major factor that contributes to the movement of water
- When water is lost due to transpiration, it causes the generation of a suction force, leading to the water moving up the plant
- This suction force is called the transpirational pull
- The stream of water that can be seen moving up towards the plant due to this effect is called a transpiration stream

- The importance of transpiration

- Helps move the water from the roots all the way to the leaves
- Helps reduce the latent heat as the water evaporates from the leaf, which in turn helps in cooling down the plant
- Provide water to cells to be used in photosynthesis, and for maintaining the turgidity of the cells

- Factors affecting rate of transpiration

- Temperature, wind speed and light intensity have direct relation with transpiration, while humidity has inverse relation,

Temperature	→ As temperature increases, the rate of transpiration also increases → Increase in temperature means increase in average kinetic energy of water vapour particles; higher kinetic energy means faster rate of evaporation and diffusion, which results in faster loss of water
Humidity	→ Humidity is a measure of water vapours present in air. → More humidity means less concentration gradient; slower rate of diffusion of water vapours out of plant into air; hence increase in humidity decreases the rate of transpiration
Wind Speed	→ Humidity is a measure of water vapours present in air. → More humidity means less concentration gradient; slower rate of diffusion of water vapours out of plant into air; hence increase in humidity decreases the rate of transpiration
Light Intensity	→ Increase in light intensity increases the rate of transpiration → As mentioned above, light causes increase in potassium ions concentration in guard cells, which results in water entering them making them turgid → As the guard cells become turgid, stomata opens and transpiration surface area increases

How wilting occurs:

- Wilting occurs when the rate of transpiration is higher than rate of water uptake, resulting in loss of turgor pressure of cells
- Turgidity of cells keep the plant firm and leaves erect
- When cells lose their turgor pressure, due to excessive water loss, they become flaccid or plasmolysed causing them to appear floppy.
- As a result of wilting, the guard cells also lose their turgor pressure and stomata closes; consequently, rate of transpiration will decrease

Unit 8: Nutrition in Human

- What is nutrition?

- It is the intake of nutrients for metabolic activities, such as growth, repair and maintenance.

Monosaccharides

- General formula of monosaccharides: $C_6H_{12}O_6$
- Some examples of the important monosaccharides are:
 - ↳ Glucose (The form in which carbohydrates are transferred around in animals' body)
 - ↳ Galactose
 - ↳ Fructose
- Sources where we can obtain these monosaccharides from:
 - ↳ Glucose: Fruits, products of starch digestion
 - ↳ Galactose: Through the hydrolysis of lactose
 - ↳ Fructose: Through the hydrolysis of sucrose

Disaccharides

- General formula of disaccharides: $C_{12}H_{22}O_{11}$
- Some examples of important disaccharides:
 - ↳ Sucrose (the form in which carbohydrates are transferred in plants)
 - ↳ Lactose
 - ↳ Maltose

- Condensation and Hydrolysis of Disaccharides:

- **Condensation:** When small molecules join to form a large molecule with the removal of water
 - ↳ $C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11} + H_2O$
- **Hydrolysis:** When large molecules break up into smaller molecules with the addition of water
 - ↳ $C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$

Disaccharides	Condensation	Hydrolysis
Sucrose	Glucose + Fructose → Sucrose + Water	Sucrose + Water → Glucose + Fructose
Lactose	Glucose + Galactose → Lactose + Water	Lactose + Water → Glucose + Galactose
Maltose	Glucose + Glucose → Maltose + Water	Maltose + Water → Glucose + Glucose

Polysaccharides

- They are of two types:
 - ↳ **Storage polysaccharides** = Glycogen, Starch
 - ↳ **Structural polysaccharides** = Cellulose

Polymerisation

- When many small units (monomers) combine to form a very large unit (polymer)
- General formula: $(C_6H_{10}O_5)_n$

Dietary Importance and Principal Sources

	Principal Sources	Dietary Importance
Carbohydrates	→ Grains: wheat bread, pasta, rice and cereal. → Starchy vegetables: Potato and corn → Dairy products: milk and yoghurt	→ Aerobic respiration for energy → Formation of cell wall from cellulose → Formation of nucleic acids → Synthesis of mucus → Synthesis of nectar in flowering plants
Proteins	→ White meat: chicken, turkey and fish → Eggs → Legumes: lentils, chickpeas, kidney beans, etc. → Dairy products → Nuts and seeds: almond, peanuts, pumpkin seeds, etc. → Grains: quinoa, oats and rice	→ Growth and repair → Synthesis of muscles, bones, skin, hair and cell membranes → Formation of antibodies, enzymes and certain hormones → Formation of blood proteins such as fibrinogen

Lipids	→ Red meat: beef and mutton → Vegetable oils: canola, olive and sunflower oil → Fats: butter, margarine and lard → Nuts and seeds → Dairy products, especially cheese → Egg yolk	→ Source of energy → Storage compound stored in adipose tissue → Synthesis of cell membrane → Solvent for fat-soluble vitamins → Insulation to prevent heat loss
Fibre (Roughage)	→ Vegetables and fruits → Seeds and nuts	→ Promotes digestive health: adds bulk to faeces, making it easier to pass through the alimentary canal → Prevents constipation: softens the faeces by absorbing water in the intestines
Water	→ Drinking water → Fruits and vegetables → Juices and milk	→ Solvent for inorganic salts and organic compounds → Main constituent of protoplasm, mucus, saliva, blood plasma and digestive juices → Sweating helps to cool down the body → Site for many important chemical reactions → Transportation agent for blood cells, proteins, hormones and excretory products → Hydrolysis of large compounds → Activation of enzymes → Photosynthesis

Vitamins and Minerals

- Vitamins are substances needed in small, fixed amounts to healthy development and functioning of the body. There are two types of vitamins:
 - ↳ **Fat-soluble** vitamins, which can be stored in body
 - ↳ **Water-soluble** vitamins, which cannot be stored in body
- Minerals are inorganic nutrients needed in small amounts for healthy body

	Principal Sources	Dietary Importance	Deficiency	Symptoms
Vitamin C (Water Soluble)	→ Citrus fruits: oranges, lemon and lime → Fruits: strawberry, papayas and tomatoes → Raw green vegetables: spinach, kale and broccoli	→ Formation of collagen protein, which is a major structural unit for skin, bones and connective tissues → Maintenance of healthy epithelial tissue	→ Scurvy	→ Swelling and bleeding gums → Painful and swollen joints → Slow healing of wounds → Tooth loss → Muscle pain

Vitamin D (Fat Soluble)	→ Fish liver oil e.g. cod liver oil and seafood → Egg yolk → Dairy products → Exposure to sunlight	→ Essential for absorption and assimilation of calcium and phosphorus for healthy bones and teeth	→ Rickets (in children)	→ Poor bone and teeth development → Pliable bones (softening and weakening of bones; can easily be bent) → Pain in pelvis, spine and muscles → Deformities, such as bowed legs or knock knee
Calcium	→ Dairy products → Eggs → Green vegetables	→ Building and maintenance of strong healthy teeth and bones → Blood clotting → Transmission of nerve impulses	→ Rickets	→ As mentioned above
Iron	→ Animal liver → Red meat → Egg yolk → Green vegetables → Kidney beans	→ Synthesis of haemoglobin → Synthesis and proper functioning of certain enzymes such as catalase	→ Anaemia	→ Fatigue, weakness and shortness of breath → Dizziness and headache → Cold hands and feet → Low haemoglobin levels

Digestive System

- The digestive system consists of two parts:
 - ↳ **Alimentary canal** or the gut, which is the passage along which the food moves through the digestive tract
 - ↳ **Accessory digestive structures**, which are the glands associated with digestion. Accessory organs of digestion are organs that secrete substances needed for the digestion of food, but through which food does not actually pass as 'digested'. The accessory digestive structures include salivary gland, liver, gallbladder and pancreas.
- **Gland**: A gland is a cell, tissue or an organ which secretes chemicals e.g. salivary gland, pancreas, pituitary gland, etc.

- Key Terminologies:

- **Ingestion** is taking in food/drink into the body through the mouth
- **Mechanical/Physical digestion** is the breakdown of food into smaller pieces without any chemical change to the food molecules

- **Chemical digestion** is the breakdown of large insoluble molecules into small soluble molecules
- **Absorption** is the movement of small food molecules and ions through the wall of the intestine into the blood
- **Assimilation** is the movement of digested food molecules into the cells of the body where they are used, becoming part of the cells
- **Egestion** is the passing out of food that has not been digested or absorbed, as faeces, through the anus

- Reason for digestion before absorption:

- Digestion is a process in which **large, insoluble and complex biological molecules are broken down into small, soluble and simple molecules**, as a result of enzyme catalysed hydrolytic reactions
- The molecules have to be digested in order to be absorbed in the bloodstream, and transported to tissues; diffused across the cell membrane into the cells for assimilation

- Physical/Mechanical digestion:

- The breakdown of food into smaller pieces without any chemical change to the food molecules, hence increasing the surface area to volume ratio for enzymes to effectively act.
- Takes place in various parts of alimentary canal:
 - ↳ Chewing by teeth
 - ↳ Churning of food by the stomach
 - ↳ Emulsification of fats by bile

Mouth/Buccal Cavity

- Structure:

- There are 2 **jaws** present in the mouth cavity: upper jaw and lower jaw
- The upper jaw is fixed at its position, while the lower jaw is movable
- Along the teeth, the mouth contains a tongue and salivary glands
- Physical/mechanical digestion takes place in the mouth with the help of the **teeth**
- Chemical digestion takes place in the teeth with the help of the enzyme, amylase, secreted by the **salivary gland**
- The mouth has a pH that ranges from 6-7, which is optimum for amylase

- Function:

- **Ingestion** takes place in mouth i.e. food enters into the body through the mouth
- The mouth does **physical digestion** by breaking down large food pieces into smaller pieces; this helps in increasing the surface area to volume ratio of food for enzymes to act on during chemical digestion

- Salivary glands (accessory digestive structures) open into the mouth through the ducts, which secrete saliva (spit) into the mouth. Saliva contains salivary amylase, which is an enzyme that **chemically digests** starch into maltose.
- The tongue has **taste receptors**, which allow us to taste the food. The food is rolled up by the tongue into small, slippery, spherical masses known as boli.

- Types of Teeth

- There are two jaws present in the mouth: upper jaw and lower jaw
- Each jaw contains equal number of teeth i.e. 16 each and 32 total, which are :

Teeth	Location	Structure	Function
Incisors	Present on the front side	Chisel-shaped	Biting and holding the food
Canines	Present next to the incisors	Sharp-pointed	Tearing the food
Premolars	Present behind the canines	Large and flat Usually have 2 cusps	Grinding of food Chewing the food Crushing the food
Molars	Present behind, in the back of the mouth	Large and flat Usually have 4-5 cusps	Same as pre-molars

- Tooth Structure

- Crown is the visible part of the tooth
- Root is the part of the tooth under the gums

Tooth structure	Function
Gums	Teeth are embedded in the gums
Enamel	The outer part of the tooth is known as enamel, which is mainly composed of hydroxyapatite, which is a mineral form of calcium phosphate
Dentine	The layer under the enamel is known as dentine, which is made up of hard tissue and is calcified. Dentine contains microscopic tubules; if the protective layer over dentine i.e. enamel is damaged then the tubules allow heat, cold, acidic or sticky foods to stimulate the nerves and cells inside the tooth, causing sensitivity.
Pulp	Pulp is the inner structure of the tooth, which is soft; contains blood Vessels and nerve endings
Cementum	A layer of connective tissue that binds the roots of the teeth firmly to the gums and jawbone.

Oesophagus

- Oesophagus, the gullet, is a part of the alimentary canal which is a narrow, muscular tube
- Bolus from the mouth goes down into stomach through oesophagus, through the process of peristalsis
- Oesophagus has a pair of antagonistic muscles, known as longitudinal and circular muscles. These muscles work together, but in opposite directions to each other.

- Peristalsis

- Peristalsis is the rhythmic wave-like movement of an antagonistic pair of muscles i.e. circular muscles and the longitudinal muscles
- When the food moves down the alimentary canal, the circular muscle behind it contracts and longitudinal muscles relax; this constricts the lumen. Constriction of lumen makes it narrower and longer from behind, exerting a force that pushes the food forward
- Simultaneously, the circular muscles ahead of the food relax and the longitudinal muscle contracts, dilating the lumen. Dilation of the lumen makes it wider and short, helping the food to enter forward.
- Mucus helps to reduce friction between the food and wall of alimentary canal, making peristalsis easier

Stomach

- Functions of stomach:

- Temporary stores food until it passes to the small intestine through pyloric sphincter muscle
- Churning
- Chemical digestion of proteins
- HCl (hydrochloric acid) kills pathogens, acting as a chemical barrier against diseases

- Physical digestion in stomach

- Churning is a type of physical digestion, where walls of the stomach rhythmically contract and relax
- This allows mixing of bolus with the digestive juices and HCl present; squeezing the food increases the surface area to volume ratio for enzymes to act on
- The liquid formed after churning is known as chyme, which moves into the duodenum

- Chemical digestion in stomach

- The gastric juice is secreted by the gastric glands present on the walls of stomach, which is a dilute solution of HCl along digestive enzymes; has a pH of around 2

- HCl inhibits the action of salivary amylase by denaturing it, while providing acidic medium optimum for activity of protease enzymes in stomach
- Main enzyme secreted in the stomach is pepsin, which breaks down proteins into polypeptides

Small Intestine

- As chyme enters the duodenum it stimulates the following functions to take place:
 - ↳ Gallbladder to release bile
 - ↳ Pancreas to secrete pancreatic juice
 - ↳ Intestinal glands to secrete intestinal juice

- Bile

- Bile is a greenish-yellow liquid which contains bile salts and bile pigment, giving it its colour. It is alkaline in nature.
- Produced by the liver, and temporarily stored in gallbladder (attached to the liver), and it is released into the duodenum through the bile duct
- Bile does not contain any enzymes, therefore, it does not chemically digest chyme
- It neutralises the chyme which comes from the stomach, making pH optimum for enzymes acting in duodenum
- Bile emulsifies fats: emulsification is a form of mechanical digestion, where it breaks large fat globules into minute fat droplets, increase surface area for lipase enzymes to act on it
- Bile salts also reduce the surface tension of lipids, assisting in emulsification of fats

- Pancreatic Juice

- Pancreas is connected to duodenum with pancreatic duct through which pancreatic juice travels into duodenum
- Pancreatic juice contains digestive enzymes which are:
 - ↳ Pancreatic amylase, which breaks down remaining starch into maltose
 - ↳ Pancreatic lipase, which breaks down fats into fatty acids and glycerol
 - ↳ Trypsin, which breaks down proteins into polypeptides

- Intestinal Juice

- Intestinal juice is secreted by the lining of the walls of the small intestines which bear glands.
- Intestinal juice contains digestive enzymes which are:
 - ↳ Erepsin/peptidase, which breaks down polypeptides into amino acids
 - ↳ Intestinal lipase, which breaks down fats into fatty acids and glycerol
 - ↳ Maltase, which breaks down maltose into glucose
 - ↳ Lactase, which breaks down lactose into glucose and galactose
 - ↳ Sucrase/invertase, which breaks down sucrose into glucose and fructose

- End products of digestion

- Carbohydrates: glucose, galactose and fructose

- Proteins: amino acids
- Lipids: fatty acids and glycerol
- Vitamins and minerals: not digested as they are already soluble and diffusible
- Cellulose: not digested by our gut, as we don't have the enzyme cellulase

Absorption and Assimilation

- Absorption of digested nutrients mainly takes place in the ileum of the small intestines, which is adapted to carry out this in the following ways:
 - ↳ Large diameter, increases the surface area for absorption
 - ↳ Numerous transverse folds, which increases the surface area to volume ratio for maximum absorption
 - ↳ Millions of minute like projections known as villi, which further increases the surface area
 - ↳ Epithelial cells of villi bear many microvilli, to increase surface area
 - ↳ The wall of villus is one-cell thick, decrease distance and resulting in faster rate of diffusion
 - ↳ The intestinal wall is richly supplied with blood vessels and lacteals, for faster and efficient absorption
- Absorption is the process by which digested nutrients are taken up by the cells lining the small intestine, and then transported into the bloodstream or lymphatic vessels for distribution throughout the body.
- Assimilation is the process by which the absorbed nutrients are taken up by the bloodstream or lacteals, and used up by the body's cells for various functions

End products	Absorption	Assimilation
Glucose, Galactose and Fructose	→ Move from the intestines into the cell linings and then into the blood → Initially by diffusion, then active transport, depending upon the concentration gradient	→ Excess glucose is converted into glycogen and stored in liver → Uses discussed under diet
Amino Acids	→ Capillaries of villi will unite to form hepatic portal vein, which carry these nutrients to the liver from small intestine once absorbed	→ Excess amino acids are deaminated in the liver - Uses discussed under diet
Vitamins and Minerals		→ Fat- soluble vitamins such as vitamin D is stored in liver → Uses discussed under diet
Fatty acids and glycerol	→ Move from the intestines into the cell linings and then the lacteals, into the lymphatic system	→ Excess stored in adipose tissue

	→ Initially by diffusion, then active transport, depending upon the concentration gradient	→ Uses discussed under diet
Water	→ About 80-90% of water is absorbed in the small intestine, while remaining in the large intestine	→ Discussed under diet

- Egestion/Defecation

- The undigested and unabsorbed passes into the large intestine and the faeces moves through the colon
- Cellulose adds bulk to the faeces and also helps in absorption of water to make faeces soft; hence, helping in bowel movement
- Faeces are stored temporarily in the rectum, before being discharged through the anus
- Egestion is different from excretion, as the faeces have not actually entered the body cells before removed from body

Unit 9: Human Gas Exchange

- Features of Gas Exchange Surfaces (Alveoli) in Humans:

- Large surface area
- Thin surface
- Good blood supply
- Good air supply

- Differences between composition of exhaled and inhaled air:

Gas	Inspired Air (%)	Expired Air (%)	Explanation
Nitrogen	79	79	Not used/ produced by bodily processes
Oxygen	21	16	Used up in respiration
Carbon dioxide	0.04	4	Produced in respiration
Water vapour	Variable	Saturated	Due to the lining of moisture inside alveoli

Pathway of air in the body

- Nose

- The nose has two nasal passages that have hair
- Nasal hair traps dust and other pathogens, acting as a physical barrier against diseases

- Larynx

- The air from the nose travels to pharynx, and then passed to the larynx

- Trachea and Bronchi

- Trachea is supported by c-shaped cartilages that prevents it from collapsing under pressure, and further divided into two tubes known as bronchi
- These are the two tubes that connect with each of the lungs
- Each bronchus is further divided to form bronchioles, and eventually ends into an alveoli
- The epithelium lining present on the walls of the **trachea** and the **bronchi** have the following cells:

- ↳ **Goblet cells**, which secrete mucus. The mucus traps foreign particles.
- ↳ **Epithelial ciliated cells** have cilia, that flick in continuous fashion to move mucus, trapped with foreign particles, away from lungs.

- Alveoli

- These are the clusters or air sacs
- Are extremely thin, have a moist wall and are well supplied with blood capillaries

- Adaptations of Lungs:

- The lungs are elastic, which helps them in contracting and relaxing easily when needed
- The number of alveoli that are present help provide a large surface area
- Lungs lie in the pleural cavity, which gets completely filled when the lungs are expanded

- Diaphragm

- Separates the thorax from the abdomen
- It flattens when it contracts, which increases the volume of pleural cavity
- It arches upwards when it is relaxed, which decreases the volume of pleural cavity

- The breathing system

Note: Diagram to be Added

- Volume & Pressure Changes in the Lungs

- The **diaphragm** and **intercostal muscles** control the movement of air in and out of the lungs.

	Diaphragm	Volume in Thorax Pressure in Lungs	Intercostal Muscles	Rib Cage
Inhaling / Inspiration	Contracts Flattens	Volume Increases Pressure Decreases	External Contract Internal Relax	Upwards and Outwards
Exhaling / Expiration	Relaxes Goes upward	Volume Decreases Pressure Increases	External Relax Internal Contracts	Downwards and Inwards

Unit 10: Respiration

What is respiration?

- Respiration is a series of chemical reactions controlled by enzymes to release energy from glucose in all living organisms
- This energy is used to bring about various life processes described below in the table:

Muscle Contraction	→ Peristalsis → Intercostal muscles → Vasodilation	→ Pupil constriction → Sphincter muscle → Vasoconstriction
Protein synthesis	→ Proteases → Carbohydrases → Lipases	→ Haemoglobin → Insulin → Antibodies
Cell division	→ E.g. New RBCs formed to replace dead cells	
Growth	→ Permanent increase in dry mass	
Active Transport	→ Root hair cells to intake ions → Absorption in Intestine → Selective reabsorption in nephrons	
Nerve Impulse	→ Reflex action → Muscles and glands	
Body Temperature	→ Maintaining constant body temperature	

Aerobic and Anaerobic respiration

- Aerobic respiration is the oxidation of glucose in order to release large amounts of energy, with carbon dioxide and water as the waste products.
- Anaerobic respiration is the breakdown of glucose in the absence of oxygen, to release a relatively small amount of energy.

	Aerobic Respiration	Anaerobic Respiration (Humans)	Anaerobic Respiration (Yeast)
Reactants	Glucose and oxygen	Only glucose	Only glucose
Products	Carbon dioxide and water	Only lactic acid	Ethanol and carbon dioxide
Energy yield	High	Low	Low
Word Equation	Glucose + Oxygen → Carbon dioxide + Water	Glucose → Lactic acid	Glucose → Ethanol + Carbon dioxide
Chemical Equation	$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$	-----	$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

- Anaerobic respiration in yeast is also termed as alcoholic fermentation, as this process results in the formation of alcohol
- During anaerobic respiration glucose is partially broken down into alcohol or lactic acid, which is why there is a small amount of release of energy. Energy is still stored in bonds of these products.

- Physical activity and its effect on breathing:

- **Increase** in energy requirements, due to **strenuous exercising**, leads to more aerobic respiration taking place, for which more oxygen needs to be provided, while simultaneously, more carbon dioxide has to be removed from the body cells
- This **increases** the **breathing rate**, for rapid gas exchange, and **heart rate**, for quicker transport to meet the body's **increased oxygen demand**
- If vigorous exercise **continues**, and the energy requirement is not met, then the body starts to **respire anaerobically** alongside, producing **lactic acid**
- A **high build-up** in the amount of **lactic acid** can cause **muscle soreness**, as it **lowers** the **pH**, which is not optimum for enzymes. Muscles in this state are said to be in a state of **fatigue**, leading to 'oxygen debt'
- **Oxygen debt** refers to the **temporary shortage** of **oxygen** supply to the body's tissues during physical activity

- After Physical Activity:

- **Breathing rate** and **heart rate continue** to remain **high** after exercise to **repay the oxygen debt** i.e. restoring the body's normal oxygen levels
- This is done by transporting **excess lactic acid to the liver**, where it gets broken down by reacting it with **oxygen**

Unit 11: Transport in Humans

- Blood vascular system

- It has two constituents:
 - ↳ Blood
 - ↳ Heart and the blood vessels

- Blood

- The composition of blood is as follows:
 - ↳ 55 % blood plasma
 - ↳ 45 % blood corpuscles (Blood Cells)

- Plasma

- It is a non-cellular, non-living, transparent, liquid part of the blood that mainly acts as a medium of transportation for all substances in the body, except for oxygen
- Transport of nutrients, for e.g. glucose, amino acids and vitamins to all cells of body in need
- Transport of ions to maintain proper functioning of body processes, and to maintain the osmotic pressure of body
- Transport of CO₂, usually in the form of bicarbonate ions before exhalation
- Transport of different metabolic wastes, such as urea and uric acid to the site of excretory organs like kidney
- It carries fibrinogen to the site of injury for clotting
- Transports antibodies from lymphocytes to the site of infection

Blood corpuscles

- The three types of blood corpuscles are:
 - ↳ Red blood cells
 - ↳ White blood cells
 - ↳ Platelets

- Red blood cells (erythrocytes)

- The following are the features and adaptations of the red blood cells:
 - ↳ **Biconcave**: increases **surface area to volume ratio**, for **faster rate** of absorption of oxygen
 - ↳ **Absence of nucleus** and other **organelles**: allows for more space to be available for **haemoglobin**
 - ↳ **Flexible**: so they can pass **squeeze** through **capillaries** in the body
 - ↳ **Haemoglobin**: shows a high affinity for **oxygen**; binds with it reversibly to form **oxyhemoglobin**, for transport
 - ↳ RBCs are made in the **bone marrow** and have a life span of 3-4 months

- White blood cells (leucocytes)

- The following are the features of the white blood cells:
 - ↳ Usually **larger**
 - ↳ Roughly **spherical**
 - ↳ **Nucleated**
 - ↳ Produced in the **bone marrow**
 - ↳ Life span is **variable**
 - ↳ They play an important role in providing **immunity** to the body against **pathogens**
 - ↳ **Fewer** in number as compared to RBC's

- Types of white blood cells

- There are two types of white blood cells:
 - ↳ Phagocytes
 - ↳ Lymphocytes

- Phagocytes

- **Lobed** and irregular nucleus
- More **flexible** (can even move out of the capillary pore)
- **Granulated** cytoplasm
- The phagocytes kill bacteria by engulfing them with the help of cytoplasmic arms in the formed vacuole; this process is termed as **phagocytosis**. They then kill bacteria by digesting them with the help of enzymes.

- Lymphocytes

- Very **large** nucleus
- **Reduced** cytoplasm
- When bacteria attacks the body, the lymphocytes divide and increase in number to produce as many antibodies against them.
- These **antibodies** either kill the bacteria directly, or even clump up many bacteria together - this is **agglutination** - so that the whole clump is engulfed by the phagocytes.
- There are thousands of different types of lymphocytes in the body that produce different types of antibodies, as each type of bacteria or virus has a **specific protein** on its membrane (termed **antigens**) and to act on every antigen, a **specific type** of antibody is required.

- Cause of tissue rejection

- All the different types of body cells have different specific proteins on their membrane, which may vary in each person. For example, blood group A has the antigen A, and blood group B has the antigen B.

- Whenever a foreign antigen enters the body, the lymphocytes get **activated** and produce **specific antibodies** against that antigen to kill them. That's why, when we transplant an organ in a person - if the antigens on all the cells are not matched with the body's antigen system - the tissue is rejected.

- Platelets

- They play an important part in bringing about **blood clotting**
- Not considered cells, but **fragments** of the cytoplasm

- The mechanism behind blood clotting

- At the site of injury, platelets, along with the clotting factor **prothrombin factor** (**Thrombokinese**) and **calcium ions**, are released
- The **prothrombin activator** converts **prothrombin** to **thrombin**
- Thrombin, in turn, converts **fibrinogen** (soluble) into **fibrin** (insoluble)
- **Fibrin** forms a **mesh-like structure**, which traps **red blood cells**
- A clot is formed, which **stops bleeding** and **entry of pathogens**

Blood circulatory system

- It is of two types:
 - ↳ Single circulatory system
 - ↳ Double circulatory system

	Single circulation	Double circulation
Organisms	Fishes	Vertebrates except fish
Mechanism	The heart has to pump the blood once only to circulate the blood throughout the body	- The heart pumps the blood twice to circulate blood throughout the body i.e. blood passes through heart twice in one complete circuit - Includes pulmonary circulation and systemic circulation
Efficiency	Less efficient as blood flows at low pressure	More efficient as blood can flow at higher pressure
Blood	Oxygenated and deoxygenated blood is mixed	Oxygenated and deoxygenated blood is separated
Heart Chambers	2 chambers: atrium and ventricle	4 chambers: two atria and 2 ventricles

- The heart

- The wall of the heart contains cardiac muscles that show continuous involuntary actions
- The left ventricle has the thickest wall; it contains more cardiac muscles for very strong contractions in order to generate a high pressure, as it has to pump the blood throughout the body
- The right and the left side of the heart are separated by the septum, which prevents the mixing of oxygenated and deoxygenated blood in these regions respectively
- Valves prevent the backflow of blood from the ventricles to the atria during ventricular systole (contraction) and backflow of blood from aorta and pulmonary artery during ventricular diastole
- Systole (contraction) and diastole (relaxation)
- When ventricles contract to push blood out of the heart, the atrioventricular valves shut close to prevent backflow of blood. This is known as systole.
- When the ventricles relax, as blood flows out through the aorta and pulmonary artery, the semilunar valves shut close. This is known as diastole.
- The atrial and ventricular contractions occur at different times, as they both push the blood in opposite directions i.e: downwards and upwards respectively.
- The atrial contraction is thus termed atrial systole and the ventricular contraction is termed ventricular systole.

- Pressure changes

- During systole and diastole, heart valves open and close as a result of pressure changes
- Valves are an important mechanism to stop blood from flowing backwards
- During ventricular diastole, the heart is relaxing
- The atrioventricular valves are opened, and the semilunar valves are closed
- During ventricular systole, the heart contracts and pushes blood out of the heart
- During this time, the atrioventricular valves are closed and the semilunar valves are open

- Arteries

- Endothelium refers to cells that line the interior surface of blood vessels and lymphatic vessels, forming an interface between circulating blood or lymph in the lumen and the rest of the vessel wall
- It is a thin layer of simple, or single-layered, squamous cells called endothelial cells
- The innermost layer, tunica intima, consists of lining, a fine network of connective tissue, and a layer of elastic fibres bound together in a membrane pierced with many openings
- The tunica media, or middle coat, is made up principally of smooth (involuntary) muscle cells and elastic fibres arranged in roughly spiral layers
- The outermost coat, or tunica adventitia, is a tough layer consisting mainly of collagen fibres that act as a supportive element
- Arteries consist of no valves except aorta and pulmonary artery, which has semilunar valves

- Veins

- Like arteries, the walls of veins have three layers: an inner layer, or tunica intima, a middle layer, or tunica media, and an outer layer, or tunica adventitia
- The tunica intima differs from the inner layer of an artery, particularly in the arms and legs; it has valves that prevent backflow of blood, and the elastic membrane lining the artery is absent in the vein, which consists primarily of endothelium and scant connective tissue
- The tunica media, which in an artery, is composed of muscle and elastic fibres, is thinner in a vein, and contains less muscle and elastic tissue, and proportionally more collagen fibres (collagen, a fibrous protein, is the main supporting element in connective tissue)
- The outer layer (tunica adventitia) consists chiefly of connective tissue and is the thickest layer of the vein

Note: Names of layers of both veins and arteries are not a part of the syllabus.

- Differences between arteries and veins

	Arteries	Veins
Direction	Away from the heart	Towards the heart
Blood	Oxygenated blood except for the pulmonary artery	Deoxygenated blood except for the pulmonary vein
Pressure	High pressure	Low pressure
Lumen	Small lumen to maintain high pressure	Large lumen as blood is travelling at low pressure
Structure	Thick muscular walls and elastic tissue to withstand the pressure	Thinner muscular walls and less elastic tissue, as blood travels at lower pressure
Valves	Not present, except for aorta and pulmonary artery, which have semilunar valves	Present to prevent backflow of blood

- The Main Arteries of the Body

- The arteries leaving the heart are the pulmonary arteries from the right ventricle and the aortic arch from the left ventricle.
- From the dorsal aorta, the following main arteries are given off:
 - ↳ The hepatic artery to the liver
 - ↳ The mesenteric arteries to the intestines
 - ↳ The renal arteries, one to each kidney

- The Main Veins of the Body

- Blood is returned to the heart by the main veins as follows:
 - ↳ The pulmonary veins bring blood from the lungs to the left atrium of the heart
 - ↳ Vena cava, which opens into right atrium
- Other veins include:
 - ↳ The renal veins bringing blood from the kidneys
 - ↳ The hepatic vein bringing blood from the liver
 - ↳ The hepatic portal vein bringing blood from the intestines to the liver

- Capillary

- It has a single wall made up of a single layer of cells of epithelium, termed 'endothelium'
- The wall of the capillary contains many small pores or gaps that allow the exchange of materials with the tissue fluid
- The diameter of capillaries is extremely small, sometimes even smaller than red blood cells. Due to this, they can easily penetrate through all the pores of the tissues; increases the rate of diffusion

- Tissue fluid

- It is the fluid present between the regions of the cells of tissues and hence is also called intercellular fluid or interstitial fluid.
- Formation of tissue fluid:
 - ↳ Since blood pressure is extremely high at the start of capillaries, everything in the blood plasma (water, ions, glucose, etc.) flows out through the capillary pores to form the tissue fluid, except for red blood cells and large proteins
 - ↳ At the other end of the capillaries, since the pressure is relatively reduced and the concentration of the the solute is very high, the water potential is lowered, due to which the fluid flows back into the blood
 - ↳ It provides a medium for exchange of, e.g: important nutrients, between the blood and the cells of the tissue, for them to reach the cells and for the removal of metabolic waste from all the cells

- Mechanism of heart contraction

- Cardiac cycle: One complete systole and one complete diastole represent a single cardiac cycle in four steps:
 - ↳ Atrial systole
 - ↳ Ventricular systole
 - ↳ Atrial diastole
 - ↳ Ventricular diastole
 - ↳ The sounds of heartbeats are 'lub' and 'dub'
 - ↳ The 'lub' sound is produced during ventricular systole due to the closing of A.V. valves
 - ↳ The 'dub' sound is produced during ventricular diastole due to the closing of semi-lunar valves
 - ↳ A heart beats 72 times per minute
 - ↳ 1 heart beat is completed in 0.8 seconds

Note: Although the brain plays an important role in the heart rate, the beating of the heart is initiated on its own by a specialised structure present in the right atrium called the 'sino atrial node' (pacemaker of the heart).

Coronary heart diseases

- Due to ageing or other factors, fatty deposits build up inside arteries, especially the coronary artery, which are then followed by clot formation due to damage. This leads to more fat deposition; hence more clot formation inside.
- This is called atherosclerosis, which then blocks the lumen, restricting the blood supply to one point of the heart
- This causes severe chest pain known as angina, and if the blood supply is completely blocked, it may result in a heart attack, or even death.
- If the main coronary artery is blocked, it may lead to heart failure

- Causes of coronary heart diseases

- It may be through heredity (passed on from one person to another through inheritance)
- High cholesterol in blood
- More saturated fats in the diet e.g. fat sources from animals
- Obesity
- Aging
- Smoking, as tobacco contains nicotine, which leads to atherosclerosis.
- High intake of salt, which increases blood pressure
- Gender (more in males)
- Stress, which increases blood pressure

- Precautionary steps

- Although some of the factors that cause C.H.D cannot be controlled (age, gender, and heredity), there are other preventive measures that can be taken to reduce its risk, e.g:
 - ↳ A healthy diet which is low in fat, especially saturated fats
 - ↳ Quitting smoking
 - ↳ Exercising regularly e.g. running and jogging
 - ↳ Managing stress

Unit 12: Disease & Immunity

- A **pathogen is a disease causing organism**
- Pathogens include bacteria, viruses and some protoctist
- Organisms that have these pathogens are known as hosts
- Pathogens are passed on from one host to another, and are hence known as transmissible diseases
- Pathogens can be **passed on through either direct or indirect contact**
- Direct contact means the passing of pathogens through bodily fluids, such as blood or semen
- Indirect contact means the passing of pathogens from one host to another without touching or the passing of bloody fluids.
- This can include touching contaminated surfaces, consuming contaminated food and water, through air, and insect bites such as by malaria vectors or other animals

- Body's Defences Against Infection:

- There are three main ways through which the body stops the passing of pathogens:
 - ↳ Mechanical barriers
 - ↳ Chemical barriers
 - ↳ Cells
- Mechanical barrier is the first in line in defending the body from infections. It includes the **skin** and **hairs** present in the nose.
- If there is a cut in the skin, it immediately starts to heal itself, forming a scab, to prevent entry of pathogens into the bloodstream
- The hair in the nose catch the pathogens to stop them passing the barrier of the nose and going towards the lungs
- If pathogens are able to pass the mechanical barriers, then the chemical barriers come into action; these includes **mucus** and **stomach acid**
- Mucus traps the pathogens and is removed through coughing or blowing the nose
- Stomach acid kills the pathogens if mucus, skin and nose hairs are unable to stop them
- Cells come in action after the pathogens have infected the body, as an immune response. This includes the engulfing of pathogen cells, also known as phagocytosis, or producing antibodies and agglutination.

The Spread of Malaria and role of Mosquitos:

- Malaria is caused by the protozoan parasite **plasmodium**
- The vector of malaria is a female Anopheles mosquito
- A vector is **an organism which transmits parasites/pathogens from one organism to another**

- How mosquitos play a part in spreading malaria (transmission)

- A female mosquito (she does not have the parasite) bites an infected human (the human is a malaria patient)
- The mosquito, using its proboscis, penetrates the skin, and it enters the bloodstream. At the same time, the mosquito secretes its saliva to protect the proboscis from human blood and stops clotting.
- The mosquito sucks the blood of the patient, and now it has the parasite in its stomach
- The parasite will now reproduce sexually and then asexually, and will slowly make its way to the mosquito's salivary glands
- Now, its saliva includes the parasite
- The mosquito (it is a vector now) bites a healthy human, sucking its blood and injecting its infected saliva
- The saliva, now containing the parasite, will travel into the bloodstream of the human. The human is now infected
- Once the parasite enters the human bloodstream, it can travel to the liver and red blood cells, causing symptoms of malaria.
- Malaria can also be spread by the transfusion of infected blood
- The symptoms of malaria are (usually occur when the daughter plasmodia cells are released simultaneously):
 - ↳ violent shiverings
 - ↳ profuse sweating
 - ↳ chills
 - ↳ fever every 48-72 hours
 - ↳ the person might get anaemic

- The preventive control measures that can be taken are:

	Control	Effect
Against plasmodium parasite		
Medicinal drugs	→ Drugs can be taken by the infected person such as quinine and malarone → A healthy person can take the drugs before the malaria attacks	→ They will not have that much effect on the parasites present in the human liver compared to in the bloodstream. → The parasites will be killed off as soon as they enter; however, plasmodium has developed resistance against many drugs, reducing their effectiveness
Precautionary measure		
Mosquito bites	→ Mosquito nets → Mosquito repellents such	→ Sleeping under the nets; use of repellents will reduce the chances of

	as coils and creams → Wearing long sleeves shirts	mosquito bites → Makes person less vulnerable to bites
Eliminating Mosquitos	→ Filling and draining of the breeding places of mosquitos (usually stagnant water) → Not allowing water to collect in empty places for too long → Spraying oil on stagnant water to form a barrier on its surface → Spraying of insecticides on walls of buildings, especially dark corners	→ Mosquitoes lay their eggs in stagnant water, hence this would decrease their population → Stops the mosquitoes from laying their eggs, while also suffocating the developing eggs, larva or pupae present, by stopping the passing of oxygen → To kill the mosquitoes
Biological measures		
Fishes	→ Introduction of breeding fishes like guppies in ponds or lakes	→ Feed on mosquito larvae and pupae

- Life Cycle of Mosquitoes

- Mosquitoes lay their eggs in stagnant water
- The eggs stick together to form rafts and float on the water's surface, providing enough oxygen for the growth. The yolk present in the eggs provides food.
- After two days, the eggs hatch and larvae emerge
- Larvae rest near the surface of the water to breathe through their spiracles
- Larvae feed on microscopic plants and animals in the water
- They grow rapidly and store a lot of food materials in their bodies.
- After one week, the larvae change into pupae
- Pupae feed on stored food in their bodies collected during the larva stage
- 5-10 days later, pupae transform into adult mosquitoes
- Adult mosquitoes emerge from the water using their wings

HIV and AIDS

- HIV are directly transmitted viruses
- HIV, which stands for Human Immunodeficiency Virus; destroys the body's immune system
- If HIV is not treated, it can lead to AIDS
- AIDS (Acquired Immunodeficiency Syndrome) completely destroys the immune system. The body is unable to produce sufficient antibodies to provide the immunity needed to protect the person against many other diseases.
- There is no cure for AIDS yet. So, normal, mild infections may be very fatal for a person with AIDS.

- AIDS is known as a **syndrome**, because it's a disease with many symptoms occurring at the same time.
- The signs or symptoms an AIDS-infected person shows are:
 - ↳ chronic fever
 - ↳ severe diarrhoea for months
 - ↳ pneumonia
 - ↳ Kaposi's sarcoma or blood vessels cancer
 - ↳ brain infection
 - ↳ widespread tuberculosis
- Victims of AIDS usually die within two years

- The modes of transmission of AIDS

- Sexual intercourse with an infected person
- Sharing non-sterilized needles with an infected person. Needles are usually shared between people doing tattooing, ear-piercing, drugs or acupuncture
- Blood transfusion with the blood from an infected person
- Passing of HIV from a mother to her foetus during pregnancy or breastfeeding
- AIDS passes from one person to another **directly**

The ways to control HIV and AIDS are:

- Keep one sex partner only, and avoid promiscuous behaviour
- Use of condoms and femidoms to not spread AIDS or other diseases
- Avoid drug abuse, as drug addicts tend to use and share non-sterilized needles amongst themselves
- Avoid the sharing of items that can tear the skin and be contaminated with blood, such as razors
- Only using sterilised needles from professional and trusted operators

Cholera

- Cholera is an acute (sudden) diarrheal illness caused by the infection of the intestine with vibrio cholerae bacteria
- People are often infected by this when they swallow food or water contaminated with the cholera bacteria
- In most cases, cholera is transmitted through the faeces of an infected person that entered a water body
- If no measures are taken, it can spread rapidly in areas lacking a proper sewage and water system
- The cholera bacteria attaches itself to the small intestine wall, where it produces enterotoxins
- Enterotoxins further promote the secretion of fluid and electrolytes, which include chloride ions into the lumen of the small intestine
- The ions gather in the lumen and lower the water potential there

- Once the water potential is lower than the water potential of the cells lining in the intestine, osmosis happens. This means water comes out from the cells.
- Causes the loss of significant amounts of water and ions from the body, leading to the tissues and organs to stop working properly

The symptoms of cholera are:

- Profuse watery diarrhoea
- Vomiting
- Thirst and severe dehydration
- Leg cramps
- Restlessness or irritability

- The ways to control cholera are:

- Bury poop/faeces
- Abstain from excreting into any water body
- Using latrines and sanitation systems
- Wash hands
- Clean latrines and surfaces with a mixture of bleach and water in the ratio 1: 9
- Proper sewage treatment
- Proper waste disposal
- If infected, drink a mixture of water with salt and sugar, which is otherwise known as oral rehydration therapy
- Avoid consuming raw or undercooked food

Alcohol

- Alcohol is a socially accepted drug, if not taken in excess
- It is a depressant, which means it slows down some cerebral functions
- Its consumption has many side effects, which will be broken down into 3 parts

Side effects	
Initial effects	→ Increased anxiety in some people → Reduced tension and worries; the person becomes carefree → More stimulated appetite than usual → Reduced self-control
Short-term (if a person starts to drink more alcohol)	→ Blurred vision → Poor muscular coordination → If the person drives, they might drive with less caution due to slower reaction time
Long-term (once alcohol abuse starts)	→ Brain becomes anaesthetised → Unconsciousness occurs → High levels of alcohol may paralyse the medulla oblongata or hindbrain, which controls breathing and heartbeats; consequently, death occurs

	→ Addiction and dependence → Once addicted, the person gets violent and may commit crimes → Increases the risk of gastric ulcers → Damages the liver and may lead to cirrhosis
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Smoking

- The reasons many people smoke are:

- Seen as symbol of adulthood and maturity
- Out of curiosity
- Relieves stress, tension and boredom
- Becomes a habit
- Peer group pressure

- Symptoms/effects of withdrawal:

- Longing to smoke
- Becoming sleepless and irritable
- Numbness in arms and legs
- Inability to concentrate on work
- Coughing more often

- Chronic obstructive pulmonary disorders (COPD)

- The chemicals found in cigarettes are: tar, nicotine and carbon monoxide
- Cigarettes contain more than 4000 chemicals, of which 50 are directly carcinogenic
- The diseases related to smoking are: bronchitis, emphysema, lung cancer and heart disease (Smoking during pregnancy is a whole different point)
- Smoking contains many harmful chemicals including:
- **Tar** is a carcinogen; it causes cancer
- **Nicotine** is an addictive substance which results in atherosclerosis
- **Carbon monoxide** reduces the oxygen-carrying capacity of the blood, by irreversibly binding with haemoglobin.

COPD	Effects
Bronchitis	Bronchitis is an inflammation of the bronchial tubes, which causes increased mucus production and further narrowing of the air passages, making it harder to breathe and causing coughing and phlegm production.
Emphysema	Emphysema causes damage to the walls of the alveoli, in the lungs where oxygen and carbon dioxide are exchanged. Partition walls between the alveoli break down because of intense coughing, enlarging air spaces and decreasing the surface area of the lungs. The person has difficulty in breathing after doing even slightly physically stimulating tasks.

Other diseases	Effects
Lung Cancer	Smokers have a higher risk of being diagnosed with lung cancer than non-smokers, because smoking enlarges the air sacs, causing breathing problems.
Heart diseases	Smokers increase their chances of building up deposits in their blood vessels when they smoke. This blocks the blood vessels and can cause heart attacks.

- Effects of smoking on pregnant women:

- Carbon monoxide and nicotine affects the development of the foetus
- The combination of CO with haemoglobin makes carboxyhaemoglobin, which cannot transport oxygen
- Nicotine causes the arteries that bring blood to the placenta to narrow, hence decreasing the amount of food substances reaching the baby
- Brain development of the foetus is affected, which will affect the child later in life
- Mother might face a lack of oxygen or chronic bronchitis
- The foetus grows more slowly and may die in the first few days of it being born, as it will be smaller and more fragile
- High risk of the baby being born premature
- High risk of miscarriage
- Baby might be born dead (stillborn)

Antibiotics

- A drug is any external administered chemical substance that modifies or affects chemical reactions in the body
- Antibiotics are chemicals that are widely used to treat many infections and diseases caused by microorganisms
- Antibiotics are produced by certain bacteria or moulds. Some are man-made as well.
- Antibiotics do not harm viruses as they are non-cellular and are taken only as a preventative measure
- They act against bacteria
- Antibiotic-resistant bacteria become so by analysing and identifying the mode of action of various antibiotics (which are taken to treat the infection)
- Due to this, the infection becomes hard to treat by the same antibiotics

- Use of antibiotics for the treatment of bacterial infections

- Antibiotics work in different ways:
 - 1) They disrupt the production of the cell wall to prevent the bacteria from reproducing
 - 2) They cause them to burst open
 - 3) They interfere with protein synthesis
- All these stop the growth of the bacteria. Animal cells do not have cell walls and they also have a different protein, because of which they remain unaffected.

- The causes of the development of antibiotic resistance:

- When proper doses of antibiotics are not taken
- When antibiotics are not taken for their proper duration (Usually 5 days, minimum)
- Too much use of antibiotics (over prescription)
- Natural selection in bacteria
- Mutation in bacteria

- How to avoid the development of resistance in bacteria:

- Proper dose of antibiotics
- Proper length of treatment (duration) with antibiotics
- Avoid use of narrow spectrum antibiotics
- Proper identification of causative organism (bacteria)
- Hygienic and aseptic conditions in areas, such as hospitals
- Try to minimise the use of antibiotics in farm animals
- An example of antibiotics resistant bacteria is MRSA, which stands for **Methicillin Resistant Staphylococcus Aureus**
- It is a cause of Staph infections that are difficult to treat because of their strong resistance to some antibiotics

Immunity

- Active immunity is the defence against a pathogen by the production of antibodies in the body.
- Active immune response happens in two ways:
 - ↳ Body has been infected with a pathogen
 - ↳ Use of vaccination
- Every cell has chemical substances on their surfaces. These are called antigens.
- Antigens are cell specific and are recognized by the phagocytes if foreign
- Lymphocytes produce proteins which are known as antibodies
- These antibodies are bacteria specific; they cannot destroy Bacteria A if they are meant to destroy Bacteria B
- Antibodies act in two ways.
 - ↳ They attach to the surface of the bacteria to mark them, which makes it easier for the phagocytes to find and ingest them.
 - ↳ Neutralise the poisonous protein that the bacteria may produce and kill them themselves
- Once the infection is dealt with, lymphocytes produce the specific antibodies in lymph nodes, where they rapidly grow in number.
- This causes the body to be more immune to that specific disease.

- **Vaccine, a chemical containing a dead/weakened version of a pathogen**, is given to humans in order to evoke the immune system's response.
- This causes the reproduction of antibodies.
- These antibodies cause the production of memory cells, which will stay in the body even after the disease is gone, providing long-term immunity.

- In vaccines, there is a:
 - ↳ Harmless form of a microorganism
 - ↳ Dead microorganism
 - ↳ Toxoid, which is inactivated toxin from bacteria.

- Herd immunity is when lots of people are getting vaccination in order to reduce getting infected and spreading infection.
- Here is where vaccinations play an important role when a transmissible disease is spreading.

- Passive immunity is a short-term, fast-acting defence against a pathogen by antibodies acquired from another individual or synthetically proven.
- It is often across the placenta and in breast milk for the baby.

- In passive immunity, the body itself does not make antibodies.

- One main example is of a mother breastfeeding her child. This helps to pass on antibodies giving passive immunity to the baby.
- This immunity acts till the baby's immune system is fully ready to respond itself.

Unit 13: Excretion

Excretion:

→ **Excretion:** removal of toxic materials and the waste products of metabolism from organisms

	Excretory product	Excretory organ
Carbon dioxide	- Waste product of aerobic respiration, which can be toxic in high concentration	- Lungs: exhaling removes it from body
Urea	- Waste product of deamination of excess amino acids - Deamination is a process, which takes place in the liver, where nitrogen-containing part of amino acids is removed. As a result, urea is formed	- Kidneys: it is removed in urine

→ Medicines and hormones are broken down by the liver and need to be excreted

→ The liver also assimilates amino acids to form proteins; excess amino acids are deaminated to form urea, while the rest can be converted into carbohydrates or lipids

- Urinary System:

Component	Function
Kidneys	Remove urea, excess salts and water from the blood as urine
Ureters	Transport urine from the kidney to the bladder
Urinary bladder	Stores urine, which is discharged at intervals
Urethra	Transports urine from the bladder to outside the body

- The need for excretion:

→ Excess water and salts can cause an imbalance in the water potential of the blood, and hence the body cells, causing them to dry out or burst

→ Urea is toxic; build-up can poison and lead to death

- Urine Formation:

- As the blood enters the glomerulus, it is filtered of all glucose, water, urea and ions, due to the pressure, this is called ultrafiltration. Large proteins and cells remain in the blood
- Then, as these substances move along the renal tubule, important molecules are absorbed back into the blood capillaries surrounding the tubule. This includes all of the glucose, some of the ions, and most of the water.
- Glucose is mainly reabsorbed in proximal convoluted tubule, by active transport
- Water is mainly reabsorbed in loop of henle, while depending upon the body's need some water can also be reabsorbed in the collecting duct to maintain constant osmotic pressure of the blood
- The rest of the unwanted substances continue forward to be formed into urine - this is called selective reabsorption.
- By the time the collecting duct is reached, urine has formed, and contains urea, excess water and excess ions.

Unit 14: Coordination and Response in Humans

Mammalian Nervous System

- The mammalian nervous system is divided into two parts:
 - ↳ Central Nervous System (CNS): Consists of the brain and the spinal cord
 - ↳ Peripheral Nervous System (PNS): Consists of all the nerves outside the brain and the spinal cord
- The nervous system allows us to detect changes in our environment and enables us to respond to them (sensitivity).
- The nervous system also helps us to coordinate and regulate body functions for the survival of the organism.
- Information is sent through the nervous system in the form of nerve impulses, which are electrical signals that travel across neurons.
- Bundles of these nerve cells (neurons) are known as nerves.
- The three main types of neurons are:
 - ↳ Sensory neuron
 - ↳ Relay/Intermediate neuron
 - ↳ Motor neuron

- Structure of Neurons:

- Cell body, which contains the nucleus
- Dendrite, which receives and takes information towards the cell body
- Axon, which takes information away from the cell body

- Identification of neurons:

	Sensory neuron	Relay neuron	Motor neuron
Dendrite	Long dendrite	Short dendrite	Short, highly branched dendrites
Axon	Axon shorter than dendrite	Short or long axon	Long axon
Cell body	Present in middle	Small at one end	Large at one end

- Reflex action:

- It is a rapid and automatic (involuntary) response to a stimulus.
- An involuntary (reflex) action does not involve the brain as the coordinator of the reaction, as you are not aware you have completed it until after you have carried it out.
- These are important for survival in case of emergency, such as quickly withdrawing a hand if it is touching a hot object to prevent burns.

- Reflex Arc:

- A reflex arc is a neural pathway that controls a reflex action.
- Once a nerve impulse is generated, it usually travels through the reflex arc into the spinal cord, instead of the brain.
- This allows for faster reflex actions without the delay of routing signals through the brain.

- Stimulus (Change in environment)

- Stimulus is detected by the receptors, which generate the nerve impulse
- Nerve impulse is transferred to sensory neurons
- Sensory neurons take the nerve impulse to CNS (Usually spinal cord)
- Nerve impulse is transferred to the relay neurons in CNS through synapse
- Relay neurons transfer the nerve impulse to motor neurons in CNS
- Motor neurons take the nerve impulse to the effector (muscle or glands)
- Effectors respond to the stimulus

- Structure of Synapse:

- **Presynaptic neuron:** The neuron which is transmitting the impulse to the next neuron
- **Post-synaptic neuron:** The neuron which receives the nerve impulse
- **Synaptic gap/cleft:** The space between two neurons across which the impulse is transmitted by neurotransmitters
- **Vesicle:** Contains neurotransmitters, which are released in the synaptic cleft
- **Receptor proteins:** Present on the postsynaptic neuron, on to which the neurotransmitters bind

- Events at Synapse:

- As the nerve impulse travels to the axon terminal of the presynaptic neuron, it triggers the vesicles, which contain neurotransmitters, to fuse with the walls of the presynaptic neuron
- The vesicles release neurotransmitters into the synaptic cleft, which diffuse down the concentration gradient into the gap
- The neurotransmitters bind with the receptor proteins present on the postsynaptic neuron

- This stimulates the second neuron to generate the impulse, which then travels down its axon
- The remaining neurotransmitters are destroyed or recycled, preventing repeated nerves generating
- Synapses ensure that impulses only travel in one direction, avoiding confusion within the nervous system if impulses were travelling in both directions

Mammalian Sense Organs:

- Sense organs are a group of receptors responding to a specific stimulus such as light, sound, touch, temperature and/or chemicals.
- Receptors are groups of specialised cells, which detect a change in the environment and stimulate electrical impulses in response.

- Structure of the Mammalian Eye

Structure	Function
Cornea	Transparent layer which refracts (bends) the light
Iris	Controls how much light enters the pupil
Pupil	Opening through which light enters into the lens
Optic nerve	Carries nerve impulses to the brain
Lens	Transparent structure which can change its shape to focus light on the retina
Ciliary muscles	Controls the shape of the lens
Suspensory ligaments	
Fovea (yellow spot)	Contains the greatest density of light receptors, specifically the con cells

- Pupil reflex (also known as iris reflex):

- The iris is made up of a pair of antagonistic muscles, known as circular muscles and radial muscles.
- These muscles work together, but oppose each other in their actions, i.e. when one contracts, the other relaxes, and vice versa.
- These changes either constrict or dilate the pupil size, hence controlling the amount of light entering the eye.
- As it's a reflex action, it is rapid and involuntary. The stimulus for this is light intensity.

- Pupil Reflex in Dim VS Bright Light:

- Photoreceptors detect a change in light i.e. a decrease or increase in light intensity.
- The table below summarises the action:

	Ciliary Muscle	Radial Muscle	Pupil	Light Entry	Mnemonic
Dim Light	Relaxes	Contracts	Dilates / Increases in size	Increases for better focus and visibility	DR. CCRD (like Doctor Card) Dim , R adial C ontract, C ircular R elax, pupil D ilates
Bright Light	Contracts	Relaxes	Contracts	Decreases to prevent damaged	_____

- Accommodation:

- To enable us to see near and distant objects, these three structures work together:
- 1. Ciliary body (contracts or relaxes)
- 2. Suspensory ligaments (pulls, slackens or tightens)
- 3. Lens (becomes thicker or thinner)

	Ciliary Muscles	Suspensory Ligaments	Lens	Mnemonic
Near Object	Contracts	Relaxes / Loosen / Slacken	Become Thicker	CCSSLL C indy's C at S ilently S nores, L aying L istlessly: C iliary C ontract, S uspensory S lacken, L ens L arger (which means thicker/fatter)
Distant Object	Relaxes	Contracts	Becomes thinner	_____

- Retina:

- The light-sensitive layers of nerve tissue at the back of the eye that receive images and send them as electric signals through the optic nerve to the brain
- The retina consists of two type of photoreceptors:
 - ↳ Con cells (for detecting light)
 - ↳ Rod cells (for detecting colour) for red, blue and green colours

Mammalian Hormones

- Hormone is a chemical substance secreted by a gland, carried by blood, which alters the activity of one to more specific target organs to bring about a change
- Collectively, all the glands which secrete hormones are known as the endocrine system
- The individual glands are known as endocrine glands

- Endocrine System

- Adrenal gland → Adrenaline
- Pancreas → Insulin and glucagon
- Pituitary gland → FSH (Follicle Stimulating Hormone) and LH (Luteinising Hormone)
- Testes → testosterone
- Ovaries → Oestrogen and progesterone

- Adrenaline:

- Adrenaline is secreted by adrenal glands.
- It is known as the “fight or flight” hormone, produced in situations where the body is in danger.
- This includes situations such as skydiving, ziplining (extreme sports), watching a horror movie, etc.
- Increases the blood-glucose concentration by stimulating the conversion of the glycogen stored in the liver and muscles to glucose, so that respiring cells can quickly get sufficient glucose for respiration
- Increases the heart rate/pulse rate so that blood - containing glucose and oxygen - can quickly be transferred to respiring cells. This is to ensure that all muscles are well prepared for high levels of activity in a flight or fight situation.
- Diverts blood flow from less essential organs, such as the alimentary canal, to the muscles, so that maximum blood can be efficiently transferred to respiring muscles.
- Stimulates the pupil to dilate so that more light can enter the eyes and send the brain signals about the surroundings, increasing awareness.

- Nervous System Vs Endocrine System

	Nervous system	Endocrine system
Composition	Made up of CNS and PNS, which consists of the brain, spinal cord and nerves emerging from them	Made up of many endocrine glands, which secrete hormones in the blood
Message	Transferred in the form of electrical	Transferred in the form of hormones,

	impulses, that travel through the neurons (electrical) Exception: Synapse	that travel through the blood (chemical)
Time	Faster, since its done by electrical means	Slower, as hormones have to travel through the blood to the target organs
Effect	Short lasting	Long lasting, until hormones are broken down by liver

Homeostasis:

- Homeostasis is the **maintenance of a constant internal environment**, irrespective of external and internal changes.
- This means that, irrespective of any changes taking place outside or inside the body, the internal environment i.e. tissue fluid around the cells remains the same for the working of each and every cell of the body.
- **Negative feedback** is a corrective mechanism through which the body maintains its homeostatic balance by keeping certain physiological factors such as temperature, blood glucose level or osmotic pressure of the blood within the set limits when it deviates away from it.

Thermoregulation (Temperature Control)

- Structure of the Skin:

- Hair follicle: Projecting out of skin
- Hair erector muscle: A hair follicle is embedded on a hair erector muscle
- Sweat glands: Wrapped around by network of capillaries
- Receptors: Present in the dermis and epidermis
- Sensory neuron: Present in the dermis near the fatty tissue
- Blood vessels: Arteriole divides into capillaries
- Fatty tissue (adipose layer): Below epidermis
- Insulation is another way to minimise heat loss to the environment.
- An insulating layer, such as that made by air over our skin trapped between hair follicles, prevents excessive heat loss by radiation, hence maintaining a constant temperature.
- The fatty tissue under the dermis acts as a layer of insulation to prevent too much body heat being lost through the skin.

	Hot day	Cold day
Sweating	The water on out skin evaporates, taking away the latent heat; cools the body	Sweating stops/decreases
Arteriole	Vasodilation: the arteriole bringing blood to skin dilates, causing more blood to flow in the capillaries near the skin; more heat loss by radiation	Vasoconstriction: the arteriole bringing blood to skin constricts, causing less blood to flow in the capillaries near the skin; less heat loss by radiation
Hair erector muscle	Relaxed: hair lies flat against the skin	Contracts: hair stands upright, causing air to be trapped in between the hair follicles; the trapped air forms an insulating layer, which prevents heat loss.
Skeleton muscles	Relaxed	Contracts: results in shivering; energy produced to make your muscles shiver gives off heat, which keeps you warm.

Blood Glucose Control:

- Glucose homeostasis is important for the survival of an organism, because glucose is used in cellular respiration as a source of energy.
- Maintaining adequate glucose levels in the blood is thus necessary for survival for the proper functioning of all body cells.
- Furthermore, if the glucose concentration in the blood changes, the water potential of the blood is also altered. This can lead to damage to blood cells, as they will gain or lose water.
- Pancreas is an endocrine gland which secretes two hormones responsible for maintaining the blood glucose concentration.
 - ↳ Insulin
 - ↳ Glucagon

- Insulin:

- Stimulates the conversion of excess glucose into glycogen by the liver and muscles, hence decreasing the glucose concentration in the blood when it is high, such as after eating a meal.

- Glucagon:

- Stimulates the conversion of stored glycogen back into glucose, hence increasing the glucose concentration in the blood when it is low, such as when fasting.

- Glucose → Monosaccharide (soluble)
- Glycogen → Polysaccharide (insoluble)

- Type 1 Diabetes

- Occurs when insulin-secreting cells (beta cells) in the pancreas are unable to secrete insulin; as a result, the blood glucose levels are not regulated.

- Symptoms:

- Increased blood glucose levels/concentration, as insufficient insulin is present, it is unable to convert excess glucose into glycogen
- Urine also contains glucose as the kidneys are unable to selectively reabsorb all the glucose, beyond set limits.
- Extreme thirst
- Blurred vision
- Weight loss

- Treatment:

- Diabetes 1 can be treated by administering the insulin
- Monitoring blood glucose levels throughout the day as the levels of physical activity and the diet affect the amount of insulin needed
- Exercise to lower glucose concentration levels

Unit 15: Coordination & Response in plants

- Just like humans, plants have a coordination system. Unlike humans, however, their response is slow
- Plants react according to their requirements and to their surroundings, such as soil, water and gravity
- Plants have two types of responses: **positive response and negative response**
- Positive response is **towards** a stimulus, while negative response is **away** from a stimulus.
- These responses are known as tropisms

- Gravitropism is a gravity **response**. In this, the plant can grow **towards gravity or away from gravity**, according to its requirements.
- In a positive response, the plant growth is towards the gravity. An example of this is roots.
- In negative response, the plant growth is away from gravity. An example of this is shoots.
- Phototropism is a light **response**. In this, the plant **grows towards or away from light**
- In response, the plant grows towards the light. An example of this is shoots.
- In negative response, the plant growth is away from the light. An example of this is roots.
- A plant's roots or shoots are to be grown in the right directions
- A root plant will hence have a positive gravitropic response and a negative phototropic response. Why? This will cause the roots to grow downwards the way roots are supposed to grow.
- A shoot plant, however, will have a negative gravitropic response and a positive phototropic response. Why? This will cause the shoots to grow upwards the way shoots are supposed to grow.

Auxin

- Auxin is plant hormone or growth substance of plants
- Chemically, it is IAA or indoleacetic acid
- It is produced in the tips of actively growing roots and shoots
- Dissolves in the cells
- Carried by active transport to regions where it can promote cell enlargement or elongation
- Auxin spreads through the plant from the tip
- In short, the response of roots and shoots to light and gravity are influenced by auxin
- In shoots, auxins stimulate growth, while in roots, they inhibit growth

- Auxins gather at the shaded side and the lower side
- In shoots, auxin will accumulate at the shaded side which will cause the cells on that side to grow faster than the cells on the light side. This will cause the shoot to bend towards the direction of light.
- In roots, auxin will accumulate at the lower side of the root, and as roots respond to gravity, the upper side of the root will grow, causing the root to dig further into the soil.

Unit 16: Development of organisms and continuity of life

Nuclear Division

- Chromosomes are thread-like structures found inside the nucleus, which contain DNA (Deoxyribonucleic) and carry genetic information in the form of genes
- A gene is a fragment of DNA, which has code for developing a particular characteristic protein
- A **diploid nucleus contains two sets of chromosomes** ($2n$) in the form of pairs, while a haploid nucleus contains only a single set of chromosomes (n).
- For example, in the human diploid cells, there are 46 chromosomes in the form of pairs, and hence 23 **pairs** of chromosomes. On the other hand, the haploid cells will have only 23 chromosomes
- A diploid nucleus is present in all the somatic cells., and a haploid nucleus is present in all gametes (sex cells).

- Cell Division

- Somatic Cells: All body cells which are not involved in reproduction, e.g. muscle cells, blood cells, skin cells and nerve cells
- Gametes (sex cells): Cells which are involved in sexual reproduction in plants and animals, e.g. sperm, ovum, pollen grain, etc.

Mitosis

- Before cells divide, nuclear division takes place, where the nucleus replicates its DNA so that each daughter cell gets the exact same copy of DNA as the parent cell.
- This is important so that the daughter cells are genetically identical to the parent cell, as they need the ability to carry out the same specialised functions as the parent cell.
- Mitosis is defined as a type of nuclear division, which gives rise to genetically identical daughter cells.
- This maintains the diploid nucleus, or in other words, the chromosome number remains the same.
- Mitosis takes place in all somatic cells. For example, if a liver cell of a human has 46 chromosomes (23 pairs) and it undergoes mitosis, two daughter cells are produced, which are genetically identical and have the same number of chromosomes i.e. 46/23 pairs.

- Importance of Mitosis

- As cells divide, new cells are generated, which result in the growth of an organism
- Mitosis helps with the repair of damaged tissue
- Replacement of dying cells, so that the specialised functions in the body continue to be performed normally
- Mitosis plays a major role in asexual reproduction, where only one parent is needed, e.g. budding and vegetative propagation

Stem Cells

- Stem cells are unspecialised cells which divide by mitosis and produce daughter cells which have ability to differentiate to carry out a specific function i.e. they become specialised.

- Examples of Stem Cells

- Bone Marrow Stem Cells:
 - ↳ These cells have the ability to divide and differentiate into red blood cells, white blood cells and platelets, which are specialised to carry out their specific functions.
- Embryonic stem cell:
 - ↳ Have the ability to divide and differentiate into any body cell.

Meiosis:

- Meiosis is a type of nuclear division, where the chromosome number is halved from a diploid to a haploid, resulting in genetically different (non-identical) daughter cells.
- Meiosis takes place in somatic cells to form gametes.
- As the nucleus becomes haploid in daughter cells compared to being diploid in parent cells, this comes to be known as reduction division.

- Cancer:

- Cancer occurs when there is a mutation (sudden change in the base sequence of DNA) in a cell cycle controlling gene, which results in uncontrolled cell division.
- As a result, unspecialized cells are produced, which form an abnormal mass of tissue known as tumour.

Asexual and Sexual Reproduction:

- Asexual Reproduction:

- Asexual reproduction is a process which results in offspring that are genetically identical to one parent.
- Only one parent is involved in asexual reproduction, and the offspring will have the same genetic code as that of the parent.

- Examples of Asexual Reproduction:

1- Binary Fission:

- Binary fission is a process by which the bacterial cells divide into two new daughter cells which are genetically identical.
- This process is a type of asexual reproduction, where only one parent is involved and the daughter cells are genetically identical to the parents.

- Process of Binary Fission:

- The single circular loop of the DNA replicates itself. The DNA of the plasmids also undergo replication.
- The cytoplasmic membrane elongates which separates the replicated DNA
- A cleavage is formed, separating the two DNA further
- Then, a cross wall is completely formed and the parent cell will divide into two new daughter cells which are genetically identical

2- Spore Formation in Fungi:

- Spore formation is another means of asexual reproduction.
- During unfavourable conditions, the organism develops sac-like structures called sporangium that contain spores.
- When the conditions are favourable, the sporangia burst open due to a buildup of pressure, and spores are released that germinate to give rise to new organisms.
- The spores are carried by wind, water or insects.

3- Vegetative Propagation:

- Asexual reproduction in plants occurs through their vegetative parts, such as leaves, roots, stems, and buds.
- This is called vegetative propagation. For example, potato tubers, runners/stolons, onion bulbs, etc. all reproduce through vegetative propagation.
- In this way, a new plant will grow and develop from a fragment or cutting of a parent plant.

Sexual Reproduction:

- Sexual reproduction is a process involving the fusion of two haploid nuclei (gametes) to form a diploid zygote, which results in the production of genetically non-identical (different) offspring, compared to the parents.
- In the process of sexual reproduction, two parents are involved, who perform sexual intercourse/pollination for the two gametes (male and female haploid nuclei) to meet and fuse together (fertilise) and restore the diploid state of cells i.e. form a zygote. Hence, meiosis is important for the production of gametes.

	Sexual reproduction	Asexual reproduction
Advantages of asexual and disadvantages of sexual reproduction		
Parents	→ Two parents are required to mate and produce fertile offsprings du, hence difficult for isolated members of society to reproduce	→ Only one parent is require
Time	→ Time taking process due to fertilisation of gametes, and development of embryo.	→ Quicker process
Energy	→ Require a lot of energy for above mentioned processes	→ Energy efficient
Population	→ Takes longer time to increase	→ Can quickly increase, when conditions are right
Advantages of sexual or disadvantages of asexual reproduction		
Genetic variety	→ Results in genetically non-identical offsprings, which increases the genetic variety	→ Genetically identical offsprings, resulting in little to no genetic variety
Natural selection	→ As a result of genetic variation, the species can adapt to environmental changes by the process of natural selection, giving a survival benefit.	→ Natural selection does not take place, due to which species are more vulnerable to changing environment as its likely all the species will have the same genetic code
Evolution	→ Contributes to evolution	→ Little to no contribution to evolution

Sexual Reproduction in Flowering Plants

- Sepals:

- Modified leaf which protects and encloses the flower during its bud stage, when petals are growing. Sepals are collectively known as calyx.

- Petals:

- Modified leaf which are large, brightly coloured, fragrant and conspicuous, to attract the insects and provide them with a landing platform. Together, the petals form a corolla.

- Reproductive Parts of a flower

Parts	Functions
Male Reproductive Parts / Stamen	
Anther	Contains pollen sacs which produce pollen grains and release them once they get mature for pollination
Filament	The thin stalk that supports the anther.
Female Reproductive Parts / Carpel / Pistil	
Stigma	The receptive top of the carpel where pollen grains land on and are collected. Pollination occurs here.
Style	It is the stalk of the carpel. Once pollen grains land on it, a pollen tube is formed through it to enable them to reach the ovary for fertilisation.
Ovary	Part of the carpel where female gametes are produced.
Ovule	Contains the female gamete inside the ovary. A plant may have more than one ovule, which results in many seeds after fertilisation.
Ovum	Female gamete present inside the ovule.

Pollination

- Pollination is the transfer of pollen grains from the anther to a compatible stigma.
- There are two types of pollination:
 - ↳ Self-Pollination: When pollen grains transfer from the anther to the stigma of flowers of the same plant
 - ↳ Cross-Pollination: When pollen grains transfer from the anther to the stigma of flowers of different plants of the same species

- Methods of Pollination:

- Plants cannot locomote (displace themselves); hence, the pollen grains have to be carried
- by a vector such as the wind, or pollinators such as birds, bees and butterflies. The plants which get pollinated through the wind are known as wind-pollinated flowers, and the ones which get pollinated through insects are known as insect-pollinated flowers.
- Both of these types of flowers are adapted in their own ways to increase the chances of pollination.

Implications of Self and Cross-Pollinated Flowers:

- Variations:

- (Differences between individuals of the same species) As a result of cross-pollination, there are more genetic variations within the population of a particular plant species.
- More genetic variation means that plants are better adapted to changes in the environment, and less vulnerable to diseases.
- Self-pollination results in less genetic variety, making the population less likely to adapt to changes and more vulnerable to diseases.

- Evolution: (The process through which species adapt over time in response to their changing environment)

- There are more chances of evolution in the case of cross-pollination; this enables some individuals to be adapted to their new situation, ensuring the survival of the species.
- There are less chances of evolution in self-pollination, due to less natural selection.

- Reliance to Pollinators:

- Cross-pollinated flowers completely depend on pollinators such as bees to transfer pollen grains from the anther to the stigma.
- This is an issue, because the population of bees is decreasing as a result of urbanisation and the use of chemicals such as insecticides.
- Hence, the extinction of insects will put cross-pollinated flowers in great danger.

Features of Wind- Pollinated and Insect-Pollinated Flowers:

Features	Wind-pollinated	Insect-pollinated
Petals	Petals are unscented and dull, usually brown or green as insects are not meant to be attracted	Petals are large, brightly coloured, fragrant and conspicuous to attract insects and provide them a landing platform
Nectar	Not present	Nectar glands are present, which secrete nectar for the insects to feed on. Nectar guides are markings present on petals to enable insects to find nectar. As they move to drink nectar they brush past the stamen (anther), and the pollen grains get hooked to their body
Stamen and Carpel	Present outside the flower	Present inside the flowers

Anthers	The anthers are loosely attached to the filaments, which are long and dangle out of the flower so that the pollen grains can easily and effectively be carried away to vast areas with the wind	The anthers are firmly attached to the filament so that insects are able to brush past them
Stigma	The stigma is hairy and feathery, to enable it to easily catch the pollen grains.	The stigma is sticky so that pollen grains get attached to it when the insects hit it.
Pollen grains	There is a higher wastage of pollen grains when they are being transferred by the wind, so the pollen grains are produced in a large quantity. Hence, it is not very energy efficient. Pollen grains are small, lightweight and smooth, giving them buoyancy to be carried away by the wind	Pollen grains are produced in a moderate number compared to those of wind-pollinated flowers, as insects have to transfer them. Pollen grains are large, heavy and sticky. They often have spikes or hook-like structures to attach themselves firmly and grip the skin of insects.

Fertilisation

- Fertilisation is the fusion of the male nucleus (pollen/generative nucleus) with the female gamete (ovum) to form a diploid zygote
- As the pollen grain lands on the compatible stigma, a pollen tube opens, through which the pollen nucleus travels to the ovule in order to fuse with the ovum
- A pollen grain consists of a generative/pollen nucleus and a vegetative/tube nucleus. When the pollen grain lands on the stigma, the tube nucleus secretes digestive enzymes to digest the wall of the stigma through the style, all the way to the opening of the ovule into the ovum, known as micropyle.
- The tube nucleus disintegrates, while the pollen nucleus will travel down the pollen tube and enter the opening of the ovule into the ovum (micropyle).
- The pollen tube absorbs water and bursts, releasing the pollen nucleus into the ovule, where it fertilises the ovum to form a zygote.

- Post Fertilisation:

- The female nucleus fuses with the male nucleus, forming a zygote. A zygote develops in the embryo after further mitotic divisions
- The embryo develops a radicle (growing root) and a plumule (growing shoot)
- The ovule develops into a seed
- The ovary develops into a fruit

- Seed and Fruit Dispersal:

- Seed/fruit dispersal is the movement, spread or transport of seeds/fruits away from the parent plant.

- Reasons for Dispersal:

- Reduce intraspecific competition between parents and offsprings for light, water and minerals, such as magnesium and nitrates in the soil
- Plants are able to colonise more areas and increase their chances of survival by reducing the competition for resources
- Seeds/fruits have to be dispersed through the wind or animals, as plants are unable to displace themselves.
- They are the two main ways through which seeds/fruits can be dispersed.

Features of Wind and Animal Dispersed fruits

Features	Wind dispersed	Animal dispersed
Fruits	The fruits are light-weight	The fruits are colourful, fragrant and edible/fleshy to attract animals
Mechanism	They have wing-like, feathery structures, which enables them to be carried by the wind easily. Some fruits have parachute-like structures, providing them with buoyancy, as they fly through the wind over a vast area.	The seeds can be passed away in the faeces as most of them are indigestible, whereas others are thrown away prior to consumption Others have hook-like structure, which enables the fruits/seeds to grip and attach on the skin of animals and be carried away.

- Seed Structure:

- **Seed coat/testa:** Protects the embryo against adverse environmental conditions
- **Endosperm:** Contains food reserves in the endospermic seeds to supply nutrients to the growing embryo. The embryo consists of cotyledons, plumules and a radicle.
- **Cotyledons:** Also contain food reserves, such as starch and lipids, which can be broken down by enzymes to nourish the growing embryo

- Plumules are the growing shoots and they grow upwards. As a result of aerobic respiration, energy is released, and the plumules eventually develop into seedlings and start photosynthesis
- The radicle is a growing root that does so downwards. As roots develop, they absorb mineral ions such as magnesium for chlorophyll production and nitrates for protein synthesis

Germination:

- Germination is the activation of enzymes in the presence of water to break down stored food in the cotyledons, making it available for aerobic respiration to provide energy to growing regions of the embryo i.e. radicle and plumule.

- Conditions necessary for Germination:

- Water Availability: Necessary for softening the testa, making it permeable for oxygen to enter, as dormant seeds have very low water content. Water is also needed for the activation of enzymes to break down stored food in the cotyledons and endosperm. These reactions are usually hydrolytic; hence, water is needed for the activation of enzymes.
- Optimum Temperature: The temperature should be optimum for the activity of enzymes. If the temperature is too high, the enzymes will denature, and if it is too low, the enzymatic activity will become slower due to less kinetic energy and a lower frequency of effective collisions.
- Oxygen: O_2 is needed for aerobic respiration in order to produce energy for cellular activities and the growth of the radicle and plumule.

Sexual Reproduction in Humans

- Male Reproductive System

Part	Function
Testes	→ Male gonads responsible for producing sperm or male gametes. → Produces testosterone. → Located outside the body in scrotal sacs.
Scrotum	→ Consists of two sacs. → Extension of tissue that supports the testes. → The scrotum helps to regulate the temperature of the testes to ensure optimal sperm production., which is lower than body temp.

Sperm Duct	→ Sperm produced in the testes move through the sperm duct, which provides a continuous pathway for semen to travel
Prostate Gland	→ Sperms move through the sperm duct by peristalsis
	→ Along the way, glands such as prostate gland open into the sperm duct, which secretes a nutritional fluid, that mixes with the sperm to form semen.
	→ The nutritional fluid in semen provides energy and nutrients that the sperm need to survive and swim to the egg, which increases the chances of fertilisation
Urethra	→ Common tube that runs down the penis and is used for both urination and ejaculation of semen.
	→ However, semen and urine are not released at the same time because of a ring of muscles in the urinary bladder called the sphincter muscle controls urination
Penis	→ An external male reproductive organ, which has a central tube called the urethra
	→ Erectile organ, which releases semen in female reproductive system for fertilisation

- Female Reproductive System

Part	Function
Pair of Ovaries	→ Female gonad where female gametes mature → Details of processes inside ovaries is mentioned later in the chapter
Oviduct	→ A tube that connects the ovaries to the uterus → Is lined with ciliated cells that help to move the ovum away from the ovary towards the uterus. → Fertilisation takes place in the oviduct, and the zygote travels through the oviduct to the uterus where it implants
Uterus	→ Is a muscular organ in the female reproductive system where the implantation of the embryo takes place, which provides a safe and nourishing environment for the fertilised egg to develop into a foetus. → The uterine wall is known as the endometrium, which thickens during the menstrual cycle in preparation for the implantation of a fertilised egg. → If fertilisation does not occur, the endometrium is shed during menstruation. → During pregnancy, the uterus grows and stretches to accommodate the developing foetus until it is ready to be born.
Cervix	→ Is a ring of muscle at the lower end of the uterus that forms a canal between the uterus and vagina in females.

	→ During pregnancy, the cervix helps to keep the developing foetus inside the uterus, protecting it from external harm. → Also produces mucus that helps to prevent infections from entering the uterus during pregnancy. → During childbirth, the cervix dilates (widens) to allow the baby to pass through the birth canal and be born.
Vagina	→ Is a muscular tube that leads from the external genitalia to the uterus in females. → During sexual intercourse, semen is deposited in the vagina which contains sperm for fertilisation of the egg. → Chemical signals in the cervical mucus help to guide the sperm towards the uterus and the oviduct where they can fertilise the egg. → The walls of the vagina are lined with rugae (folds), which allow for expansion during sexual intercourse and childbirth.

- Structural Adaptations of Sperm and Ovum:

Adaptations		
Sperm	Flagellum/ Tail	Provides motility to sperm, making them capable of locomotion. Smooth-streamlined body further helps in movement.
	Mitochondria	Produce enough energy for sperm to survive and for flagellum to beat in order for the sperm to reach the ovum.
	Acrosome	Contains digestive enzymes which digest the jelly-like coating on the surface of the egg in order to fertilise it.
Ovum	Cytoplasm	Contains energy stores such as lipid droplets, which provide energy to the dividing zygote and to the growing embryo until it implants itself in the endometrium and forms a contact with mother's blood through the placenta.
	Jelly-like Coating	Ovum changes its jelly-like coating on the surface after fertilisation so no other sperm can fertilise it by forming an impenetrable barrier.

- Comparison of Sperm and Ovum:

	Sperm	Ovum
Size	About 45-50µm (0.00045-0.0005mm)	Can be up to 0.15mm
Number	Produced in large numbers every day and around 250 million sperms are ejaculated	Out of thousands of follicles only 1 egg matures per menstrual cycle
Mobility	Able to locomote due to their flagellum	Unable to move on its own. Hence, the ciliated cells lining the oviduct have to move the ovum.

Fertilisation:

- Fertilisation is the fusion of male nuclei from sperm (male gamete) with female nuclei from the ovum (female gamete) to form a diploid zygote

Puberty:

- Puberty is the time in life when a boy or girl becomes sexually mature i.e the gonads start producing Gametes. And secondary Sexual Characteristics starts to develop.

- Secondary Sexual Characteristics:

- These are the changes which occur when a child reaches puberty and transforms into an adult.
- Controlled by Testosterone (Produced by Testes) in Male
- Controlled by Oestrogen (Produced by Ovaries) in Females

Effects of Testosterone in Males	Effects of Oestrogen in Females
→ Testes start producing sperm → Enlargement of reproductive organs (testes and penis) → Growth of facial and body hair (in pubic regions and armpits) → Larynx enlarges, which results in deepening of the voice → Muscle growth resulting in increased strength	→ Menstrual cycle starts, lasting for 28 days average until menopause → Breast development to prepare them for future milk production (for breastfeeding) → Growth of facial and body hair (in pubic regions and armpits) → Pelvic muscle dilates, making hips wider → Emotional changes such as mood swings

Menstrual Cycle

- Once a girl reaches the age of puberty, a recurring cycle starts for approximately 28 days until menopause. This cycle is known as the menstrual cycle, which leads to:
 - ↳ Development and release of an egg
 - ↳ Changes to uterus lining

- Events of Menstrual Cycle (28 days)

- Menstrual cycle can be divided into 4 phases to bring upon a complete recurring cycle

Menstruation	3-7 Days	→ Commonly known as period → Uterus lining sheds off resulting in blood loss, along with mucus and cells from the uterine wall → Pituitary gland secretes small amounts of FSH and LH, gradually increasing their concentration in the blood
The Follicular Phase	Day 1-14 (Week 1&2)	→ Follicles, containing potential eggs, start to mature → Maturation of the follicles is controlled by the FSH → During this time, the anterior pituitary gland secretes FSH and LH
Ovulation	14th Day	→ Oestrogen levels reach their peak; it stimulates a surge in the secretion of FSH and LH → The surge of LH causes the graafian follicle to rupture and release the mature oocyte into the oviduct → This process is known as ovulation
Luteal Phase	15-28th Day	→ Following the ovulation, the remains of the graafian follicle develop into a gland known as the corpus luteum → The corpus luteum secretes progesterone and little amounts of oestrogen, which together maintain the endometrium for implantation

- Menstrual cycle is controlled and coordinated by four major hormones
 - ↳ Pituitary gland's hormones:
 - 1- Follicle Stimulating Hormone(FSH) secreted by Pituitary Gland
 - 2- Luteinising Hormone(LH) secreted by Pituitary Gland
 - ↳ Ovarian hormones
 - 3- Oestrogen secreted by ovaries
 - 4- Progesterone secreted by Corpus Luteum (present inside the ovaries)

FSH	→ Stimulates the development of follicles that contain potential eggs. → Typically, only one follicle from either ovary will fully develop into the Graafian follicle, which contains a mature egg ready for fertilisation. → Also stimulates the release of oestrogen from the developing follicles. → Causes the cells surrounding the follicles to stimulate oestrogen production.
LH	→ Stimulates the final maturation of the Graafian follicle and triggers ovulation, the release of the matured egg from the follicle. → Stimulates the transformation of the ruptured follicle into the corpus luteum, which produces progesterone to prepare the uterus for a potential pregnancy. → If the egg is fertilised, LH supports the development and maintenance of the corpus luteum, which continues to produce progesterone to support the pregnancy. → If the egg is not fertilised, the corpus luteum degenerates, leading to a drop in progesterone and triggering menstruation.
Oestrogen	→ Repairs and grows the uterine wall after menstruation. → Increases the thickness of the endometrium and blood flow, preparing it for embryo implantation. → Inhibits the release of FSH, causing some follicles to stop growing, while the dominant follicle continues to develop and undergoes ovulation. → Developing follicles stimulate the production of oestrogen, leading to increased concentration in the blood. → Peak levels of oestrogen, usually 1-2 days before ovulation, stimulate a surge in the secretion of FSH and LH.
Progesterone	→ Maintains the uterine wall, further thickening it, vascularizing it and increasing blood flow. → Inhibits the production of FSH and LH by giving negative feedback to the pituitary gland, preventing the development of new follicles. → If the egg is not fertilised, the corpus luteum starts to degenerate, leading to a fall in oestrogen and progesterone levels. → Falling levels of progesterone means that the uterine walls are no longer maintained and start to shed, leading to menstruation and marking the start of the next menstrual cycle. → As progesterone levels fall, it no longer inhibits the production of FSH. As a result, FSH will be released again, restarting the follicular phase.

Pregnancy

- After fertilisation, the zygote travels down the uterus and divides by mitosis, forming a ball of cells known as **embryo**
- Embryo implants itself on the endometrium, where it will develop into a foetus
- The gestation period (pregnancy) in humans is 9 months
- Major development of organs takes place within the first 12 weeks, during which time the embryo gets nutrients from the mother by diffusion through the uterus lining

- After organs have developed, placenta will form and the embryo is now called a foetus
- The placenta takes over the role of nourishment of the baby

- Amniotic Sac and Amniotic Fluid:

- The amniotic sac encloses the embryo, containing amniotic fluid. It has the following functions:
 - ↳ Amniotic sac protects the baby by providing it with a cushioning effect against mother's movements, pressures and acting as a shock absorber
 - ↳ The fluid insulates the baby, keeping it warm and maintaining a constant regular temperature
 - ↳ The amniotic fluid contains antibodies providing the foetus with passive immunity, nutrients for nourishment and hormones for healthy growth
 - ↳ The embryo can freely move in the amniotic fluid, allowing muscle and bone development

- Placenta and Umbilical Cord:

- During the gestation period, while the foetus is developing in the uterus, it gets its nutrients such as glucose and amino acids from the mother's blood
- Similarly all the excretory waste such as CO₂ and urea is also removed from the mother's blood. This diffusion of materials occurs across the placenta.
- Placenta is an temporary organ which develops during pregnancy and perform these main functions:
 - ↳ Secrete progesterone to maintain the uterine wall, while giving negative feedback to FSH and LH so no new follicle develops
 - ↳ Antibodies diffuse into foetal blood, providing the baby with passive immunity
 - ↳ Provide nutrients and oxygen to the foetus, while removing the waste products
- Placenta develops in the uterus, where the foetus is connected to it through the umbilical cord
- Two arteries and one vein are present in the umbilical cord
- The umbilical arteries take deoxygenated blood away from the foetus towards the placenta, where particles move down the diffusion gradient into and out of the blood
- The umbilical vein brings back oxygenated, nutrient-rich blood back to the foetus

- Adaptations of Placenta:

- The foetal blood comes in close proximity to mother's blood, but it never mixes together
- Placenta has large surface area to volume ratio and thin wall for faster rate of diffusion
- Placenta acts as a barrier against pathogens and toxins entering baby's blood
- However, placenta isn't a successful barrier against entry of all pathogens and toxins.
- Some viruses, such as rubella virus, are able to diffuse into foetal blood from mother's blood. Similarly, if the mother is smoking, then nicotine can also diffuse into foetal blood across placenta; leads to underweight baby, premature birth or stillborn

Unit 17: Inheritance

- Genes

- Transmission of genetic information through generations is called inheritance
- DNA carries the genetic information in the form of genes
- Chromosomes are located in the nucleus of a cell and other thread-like structures of the DNA
- Genes are code for the proteins playing an important role in what our cells do and hence, control our characteristics
- Alleles are different versions of a particular gene and give all organisms their characteristics

- Inheritance of Sex

- Normal human cells have 23 pairs of chromosomes and these are known as diploid cells
- Gender is determined by a specific chromosome pair
- Females have the sex chromosome XX
- Males have the sex chromosome XY
- Only the father can pass the Y chromosome and so, he is responsible for determining the sex of the child
- The father ejaculates around 250 million sperm cells during sexual intercourse, out of which 125 million sperms carry the X chromosome, while the other 125 million carry the Y chromosome
- If his X chromosome fertilises the egg, the foetus will be a female, and if a Y chromosome fertilises the egg, it will be a male
- The inheritance of sex can be shown using a punnett square, which is a genetic diagram

- Structure and function of DNA

- DNA is made up of a double helix backbone, which are connected by pairs of bases
 - ↳ Adenine always pairs with thymine (A & T)
 - ↳ Cytosine always pairs with guanine (C & G)
- The different functions of protein molecules are due to the different sequences of amino acids
- All cells in the body contain the same genes, but not all of the genes are expressed
- This is because the cell only makes a certain protein that is necessary

Manufacture of Protein

- The conversion of DNA code into proteins, which is a series of amino acids, is known as protein synthesis; it has two stages
- **Transcription and Translation**
- The sequence of amino acids that make a specific protein is determined by the sequence of bases in a gene

- Monohybrid Inheritance

- Genotype is the genetic makeup of an organism in terms of the alleles present
- Phenotype are the observable features of an organism
- Alleles are the variations of a given gene
- Homozygous are two identical alleles of a particular gene
- Heterozygous are two different alleles of a particular gene
- Dominant allele is the allele that is always expressed if present
- Recessive allele is the allele that is only expressed if the dominant allele is not present

- Variation

- Variation is the difference between individuals of the same species
- Continuous variation results in a range of phenotypes between two extremes, including body length and body mass
- Discontinuous variation results in a limited number of phenotypes with no intermediates
- This may include ABO blood groups, seed shape and seed colour in peas
- Discontinuous variation is usually caused by genes only, while continuous variation is caused by genes and the environment
- It is likely that if two people have a child together, it may not be of the same height as either of them
- Height and hair colour are both examples of continuous variation
- It is likely that people with two different blood groups may have a child with the same blood group as one of them, or have any other blood group which can include A, B, Ab or O. This is an example of discontinuous variation.

- Monohybrid Crosses and Codominance

- A monohybrid cross is a genetic cross between two people with the homozygous original types with entirely dominant or entirely recessive alleles which produce opposite phenotypes for a certain genetic characteristic
- There are different alleles that code for eye colour
- When two alleles are codominant, neither of them are dominant over the other
- As a result, the phenotype may be affected by both alleles
- Blood group is an example of codominance
- The alleles are I^A , I^B and I^O
- I^A and I^B are codominant and are dominant over I^O
- These alleles can result in different blood groups.

- Characteristics linked with Sex

- Sex-linked characteristics are those in which the gene responsible is on the sex chromosome, making them more prevalent in one sex than the other
- The colour deficiency (Xc) is an abnormal gene found in the X chromosome
- Male (XY) have only one X chromosome, so this abnormal gene will always be expressed
- Females might have the colour deficient gene, but can still have normally coloured vision because they have two X chromosomes

- DNA Mutation

- Sexual reproduction is the mixing of genes from the father and mother to produce an offspring with a completely different genetic makeup
- A chromosome mutation is a change in the chromosome number or structure, which may cause Down syndrome (47 chromosomes instead of 46, as they have one extra Y chromosome in the 21st pair)
- A gene mutation is a random change in the base sequence of DNA, which may cause sickle cell anaemia
- Mutation, meiosis, random mating and random fertilisation are sources of genetic variations in population
- Ionising radiation and some chemicals increase the rate of mutation
- **Sickle cell anaemia** is caused by mutation in a gene that codes for haemoglobin
- An abnormal base sequence of haemoglobin gene causes sickle-shaped red blood cells
- This disrupts the flow of red blood cells carrying oxygen, and they are more likely to get stuck in capillaries, preventing blood flow

Natural selection

- Natural selection refers to the idea that in a particular environment, organisms with the most advantageous characteristics are 'selected' to survive and pass on their genes to the next generation
- The procedure is as follows:
 - ↳ There is variation within the population
 - ↳ Numerous offsprings are born
 - ↳ Individuals in the population compete for resources
 - ↳ There is struggle for survival
 - ↳ Those that are more suited to their environment will live and reproduce
 - ↳ Fitter individuals transmit their genes / alleles to their children
- Natural selection ensures that only the most advantageous genes are passed onto future generations
- As a result, populations adapt to their surroundings throughout time and this is referred to as evolution

- Antibiotic Resistance

- Most bacteria of a certain strain will die when antibiotics are used
- Yet, owing to pure chance, some bacteria may have developed resistance to the antibiotics used
- These resistant bacteria grow rapidly and result in a large number of bacteria carrying the resistant gene
- Because of the increasing number of resistant bacteria, the antibiotics will eventually become useless

Artificial selection

- Artificial selection is the intentional reproduction of animals and plants by humans that have beneficial traits
- By this strategy, organisms can pass on beneficial features of their offsprings, resulting in more creatures with the desired characteristics
- Natural selection occurs when the environment provides selective pressure for creatures that dwell with in it
- Artificial selection is artificial since the pressure is applied by humans, rather than the environment

Selective breeding

- Selection of organisms with good characteristics by humans
- Crossing these organisms to create the future generation
- Offspring with desired features are chosen
- This can increase the quality of agricultural plants and tamed animals over many generations

Unit 18: Biotechnology and Genetic Modification

- Biotechnology is the application of biological organisms, systems or processes to manufacturing and service industries.
- Biotechnology and genetic modification uses bacteria. Why?
 - ↳ ability to make complex molecules
 - ↳ rapid reproduction rate
 - ↳ can be grown and manipulated without raising ethical concerns
 - ↳ have a genetic code
 - ↳ their DNA has plasmids
- Yeast is a single cell fungus that uses sugar as its food source. It has a role in the production of bread and ethanol (alcohol).
- In bread production, the flour used is a mixture of starch, protein and the amylase enzyme
- Water is added into flour to make it into a dough
- Yeast is then added into dough
- The amylase present in the dough starts to digest starch into sugar
- The protein called gluten gives the dough a sticky, plastic texture and holds the bubbles of gas
- The dough is repeatedly folded and stretched
- It is left for 1-2 hours in a bowl at a temperature of 27 Celsius
- Due to a lack of oxygen, yeasts respire anaerobically, fermenting sugar into alcohol and carbon dioxide
- The CO₂ produced causes the dough to rise, thus making cavities appear in the bread
- The alcohol produced later evaporates during baking at a temperature of 200 Celsius. It also kills the yeast.
- In ethanol or alcohol production, yeast is used in brewing
- Yeast is mixed with the sugar found in food substances used in brewing, such as grapes
- Lack of oxygen causes fermentation of sugar into alcohol and CO₂
- Examples of alcohol brewed this way are beer, sake and whiskey
- A fermenter is a giant steel cylindrical tank closed at both ends, and is designed to keep its environment favourable for the designed biological process to operate.
- Fermenters are used for large-scale production of useful products by bacteria and fungi under certain conditions.

→ Those conditions include:

↳ **aseptic precautions:** steam is used to clean the fermenter. It kills microorganisms and prevents chemical contamination, which ensures only the desired microorganisms grow.

↳ **optimum temperature:** temperature is monitored using probes and maintained using the water jacket to ensure an optimum environment for enzymes to increase activity as high temperatures can lead to enzyme denature.

↳ **nutrients:** are needed for use in respiration to release energy for growth and to ensure reproduction

↳ **pH:** monitored using probes and is adjusted using acids or alkalis.

↳ **oxygen:** needed for aerobic respiration and not needed for anaerobic respiration.

↳ **waste products:** *insert diagram*

→ Enzymes are used in biological washing powders, fruit juice production and lactose-free milk

Lactose-free milk is produced by adding the enzyme lactase to milk, which breaks down lactose (milk sugar) into glucose and galactose. These are simple sugars which do not need to be digested further, and hence make the milk safe for lactose-intolerant individuals to consume.

→ In biological washing powders, enzymes similar to digestive enzymes are present. These help in the removal of stains caused by organic molecules

→ Molecules like protein and fats are large and insoluble, and when the enzymes (protease and lipase) act on these, they become small and soluble molecules

→ This causes the molecules to pass out of the cloth easily

- The advantages are:

- Quick breakdown of large, insoluble molecules into small, soluble ones
- Effect at lower temperature, which means less energy and money is used
- Used to clean delicate fabrics not made for washing at high temperature

- Examples:

- In fruit juice production, fruit juice is squeezed out from their respective fruits
- Cutting the fruit open helps to get the most juice out, but, still not all the juice is released
- Here, pectinase is added to the chopped fruit. This enables maximum fruit juice extraction
- Pectinase breaks down the chemical pectin, which is found in cell walls. This causes the cell walls to break more easily and more juice is squeezed out
- Adding pectinase also helps to get more clearer juice
- In lactose-free milk, lactase enzyme is added to break down lactose
- Why? Lactose-intolerant people react badly to lactose as they no longer have or aren't born with lactase in their bodies
- Adding lactase makes the milk lactose-free

Genetic Modification

- Genetic modification is the **changing of genetic material of an organism by removing, changing or inserting individual genes taken from another organism**
- Once this happens, the changed organism is now known as a **genetically modified organism**
- The DNA of the organism that now contains DNA from the other organism is now known as **recombinant DNA**

- One example of genetic modification is the **production of insulin**.
- The gene for human insulin has been inserted into a bacteria which then produces human insulin. It is then collected and purified.
- Used as a medical purpose for diabetes.

- Genetic modification is also used in crop plants by inserting genes. Why?
 - ↳ to give resistance to herbicides (chemicals that kill plants)
 - ↳ to give resistance to insect pests such as caterpillars
 - ↳ to provide additional vitamins and minerals

- Wheat, maize and 'golden rice' are crops that are genetically modified now.

Advantages and disadvantages of GM crops	
Advantages	Disadvantages
Reduce the use of herbicides and pesticides, as these are diseases or pest resistant; hence, better for environment	Risk of a resistant gene spreading to wild plants by pollination, such as weeds. This will make weeds resistant to herbicides and their removal will be difficult
Increased yield, which is more profitable for farmers Crops can also be grown quicker, can cater situations like famine	Increased costs of seeds as GM crops' seeds are expensive
Better quality i.e. nutritionally or visually improved	Risk of inserted genes as, in certain cases, GM crops don't end up being successful or don't do well compared to non-GM plants
More predictable results compared to artificially selected crops	Threat to biodiversity, as insects use normal crops (non-GM) crops as food
Able to grow in extreme environmental conditions, and in new areas	

Unit 19: Relationships of organisms with one another and with the environment (Ecology)

Energy flow

- The Sun is the principal source of energy input to most biological systems
- Photosynthesis is the energy source in most forms of life, as it is a process by which plants transformed the energy of sunlight into chemical energy that can be stored and used by them and other organisms
- Most life forms on Earth are completely dependent on photosynthesis, as heterotrophs (consumers) are not able to synthesise and produce their own food
- Producers (photoautotrophs) are on the first trophic level, and all the organisms in the food chain depend on them for their energy; without producers performing photosynthesis, energy from the Sun can never be converted into chemical forms, and all life on Earth would die.

- Energy flows from the sun to the organisms:
 - ↳ To producers in the form of light
 - ↳ Producers convert light energy into chemical energy, flowing in this form from one consumer to the next
 - ↳ Eventually, all energy is transferred to the environment, e.g. as heat etc.

- At each stage of energy transfer, energy is used and lost

- **Producer:** an organism capable of making its own food
- **Consumer:** an organism that feeds on another organism to gain energy
- **Herbivore:** a consumer that gets its energy by eating only plants
- **Carnivore:** a consumer that gets its energy by eating only animals
- **Decomposer:** an organism that gets its energy by feeding on dead or waste organic material

- Food webs are networks of interconnected food chains

- They also show interdependence- how one organism depends on another for survival and how the changes in one population can affect the others within the food web
- At each stage in a food chain, only about 10% of the energy received by an organism gets passed on to the next trophic level
- Only the energy that is made into new cells remains with the organism to be passed on.
- Even then, some of this energy does not get consumed – for example, the energy that is still stored in parts of animals and plants like bones and roots remains uneaten by a few organisms, and so is not passed on.
- The majority of the energy an organism receives gets lost or used through:
 - ↳ metabolic waste products, e.g. urine, that get removed from the organism
 - ↳ as movement
 - ↳ as heat (in mammals and birds that maintain a constant body temperature)
 - ↳ as undigested waste (faeces) that is removed from the body
- Food chains usually have fewer than five trophic levels as, the longer the food chain, the less energy available to the organism at the end of the chain
- It is more energy efficient for humans to eat crop plants than to eat livestock that has been fed on crop plants, as energy is lost from that livestock, so less energy is available for humans from it

- Pyramids

- The pyramid of biomass and pyramid of energy are always upright
- The pyramid of number is not always upright
- The general rule is that the smaller the organism, the higher the number of that organism at that trophic level

Nutrient Cycles

- Carbon cycle

- Carbon cycle limited to photosynthesis, respiration, feeding, decomposition, formation of fossil fuels and combustion:
 - ↳ **Photosynthesis** uses atmospheric carbon dioxide
 - ↳ Animals **feed** on plants; hence, carbon content is passed on to the animals
 - ↳ **Respiration** releases carbon dioxide to the environment
 - ↳ When animals and plants die in conditions where decomposers are not present, they will **fossilise** over a time period of millions of years
 - ↳ When fossil fuels are burnt, during **combustion**, carbon dioxide is again given off
 - ↳ Lastly, as a result of **decomposition**, carbon dioxide is also given off to the surrounding

- Nitrogen cycle

- Nitrogen from the air cannot be absorbed by plants and animals
- However, there are two ways it can be taken out of the air and converted for it to be absorbed easily:
 - Nitrogen-fixing bacteria found living free in the soil and also in the root nodules of certain plants (called leguminous plants) take N_2 gas and change it into ammonia or ammonium ions in the soil
 - Lightning can fix N_2 gas, splitting the bond between the two atoms and turning them into nitrous oxides like nitrous oxide and nitrous dioxide that mix into rainwater and 'leach' into the soil
- Plants use the nitrates they absorb from the soil for their nitrogen to make protein while animals eat the plants or other animals to get nitrogen.
- Nitrogen returns back into the soil as waste (urine and faeces) of animals contain the ammonium compounds (the urea in urine contains nitrogen)
- When the animals and plants die, they decay and the proteins inside them are broken down into ammonium compounds and returned to the soil by decomposers
- The plants can't absorb ammonium compounds, so a type of soil bacteria, nitrifying bacteria, convert the ammonium compounds to nitrites and then to nitrates, which can then be absorbed by plants– and so the cycle goes on
- The process of conversion of ammonium compounds is known as nitrification
- Finally, there is another type of (anaerobic) bacteria, called denitrifying bacteria, found in poorly aerated soil that take the nitrates out of the soil and convert them back into N_2 gas; this process is known as denitrification

- Decomposition:

- Fungi and bacteria are the decomposers that are able to break down and digest a wide variety of organic materials, including wood, leaves, and other plant material, as well as animal waste, such as faeces and nitrogenous waste
- This process helps to recycle nutrients in the ecosystem, and a healthy balance of carbon and nitrogen in the soil is maintained, which is essential for supporting plant growth and productivity
- Without fungi and bacteria as decomposers, dead organic matter would accumulate and create a buildup of waste, leading to the depletion of nutrient levels in the soil and a decline in the health of the ecosystem

Ecosystems and biodiversity

- Population: a group of organisms of one species, living in the same area at the same time
- Community: all of the populations of different species in an ecosystem
- Ecosystem: a unit containing the community of organisms and their environment, interacting together
- Biodiversity: the number of different species that live in an area

- The factors affecting the rate of population growth for a population of an organism are food supply, competition, predation, and disease
- The growth of the human population is increasing the demand for global resources

- Effects of humans on ecosystems

- Deforestation is the clearing of forests for construction, mining, grazing purposes, etc.
- Causes of Deforestation
 - ↳ Urbanisation, as people are moving from rural to urban areas; to accommodate them, land is cleared for the construction of houses
 - ↳ Overgrazing of land by livestock, usually by those of nomadic people, who move from one place to another in the search of grass
 - ↳ Clearing land for agricultural purposes to fulfil the growing demand for global resources
 - ↳ Mining, which leads to the clearance of large areas of land, causing permanent damage to land

- It can have effects like:

Problem	Effect
Threat to biodiversity	Forests are a habitat to many species living within a community. The loss of their habitat leads to the deaths of many species dependent on forests for their shelter or nutrition. As food chains are interlinked to make a food web showing the dependence of organisms on each other, this can lead to species being endangered and extinct, which results in the loss of biodiversity, and the fragile balance of the ecosystem is affected.
Flooding	The roots of trees hold the soil intact, absorb water and reduce shock waves from water, preventing flooding. Hence, deforestation on the foothills of mountains or near coastal areas leads to increased flooding. Results in Loss of soil
Climate change	Carbon dioxide concentration Increases in the atmosphere Carbon dioxide and methane are greenhouse gases as they trap the heat from the Sun by reflecting it back into the Earth, resulting in an increased global temperature i.e. causing global warming. This results in climate change, which causes rising sea levels, increased droughts, extinction of species due to the loss of habitats and hotter temperatures along heat waves and prolonged hot days.
Overharvesting	Overharvesting of plants and animal species has led to the degradation of the ecosystem, overexploitation and depletion of some species to very

	low numbers and others being driven to extinction
Non-native species	Introduction of non-native species in an ecosystem can result in the extinctions of native plants and animals, reduction in biodiversity, competition with native organisms for limited resources, and alterations to habitats
Insecticides and herbicides	Pollution due to insecticides and herbicides can cause loss of biodiversity, bioaccumulation, and damage to beneficial insects; their high concentrations in soil can be toxic for other organisms. Bioaccumulation refers to the increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. When using excess insecticides and pesticides, at each trophic level, its concentration becomes higher than normal. This buildup of toxic chemicals is harmful for consumers.
Plastics	In the environment, in both aquatic and terrestrial ecosystems, non-biodegradable substances can harm marine life, and animals that eat plastic can get strangled or experience indigestion problems. Non-biodegradable plastics are substances that cannot be decomposed or dissolved by natural agents, such as decomposers like bacteria and fungi.

- Reasons for conservation of species with reference to:

- maintenance of biodiversity: to allow ecosystems to remain stable
- reducing extinction: helps to retain and maintain biodiversity
- protecting vulnerable environments

- Ways of conserving forest:

- Through education so that awareness about sustainable practices is known to logging companies and to consumers about the significance of buying products made from sustainable resources
- Afforestation/replanting programs to increase forest cover
- Using protected areas that help conserve ecosystems

Ways of conserving fish stocks:

- Through educating consumers about the non-sustainably produced fish (so that less are bought) and fishermen about the national and international laws
- Setting quotas and monitoring can help control the number of fish caught each year
- Controlled net types and mesh sizes so that baby fishes or some fishes for breeding are not caught
- Using protected areas
- Closed season
- A sustainable resource is one which is produced as rapidly as it is removed from the environment, so that it does not run out

Practical Work

- Basic knowledge for doing the investigations:

- As a result of photosynthesis, sugars are produced. If sugars (glucose) are produced at a faster rate than they are used, the excess sugars are converted into starch for storage. This process is known as a type of condensation polymerisation, where monosaccharides (monomers) of glucose combine together to form a polysaccharide (polymer).
- When glucose is produced from the process of photosynthesis, it is converted into starch for storage, sucrose for transport, or used up for cellular respiration. Therefore, it's more reliable to test the plant for the presence of starch through the iodine test.
- Destarching is a process in which starch is converted into glucose. When photosynthesis stops, enzymes in the leaves change starch into sugars, which are then transported into other parts of the plant. To destarch the plant, it can be placed in a dark room for 2 days. We destarch the leaf so that, before performing a test for starch, we get accurate results.

- Steps for the Test for Starch in a Leaf:

- Remove a green leaf which has been exposed to sunlight for a few hours.
- Immediately put the leaf in **boiling water**. This will kill the enzymes which convert starch into glucose/destarching will not occur. Putting the leaf in boiling water also helps to remove the cuticle, so that iodine can penetrate the leaf
- Turn off the heat and transfer the boiled leaf into a test tube containing **ethanol**.
- Place the test tube in a water bath since ethanol is flammable; it should not be put near direct flames
- The ethanol will remove the chlorophyll from the plant, making the green colour disappear
- After ethanol has removed the green pigment, the leaf will appear transparent and the ethanol becomes green. Place the leaf in water to make it soft and permeable
- Now, place the transparent leaf on a white tile and add **iodine solution** to perform a test for the presence of starch.
- In a green leaf, the whole lamina of the leaf will turn **blue-black**, (positive starch test) as photosynthesis is occurring in all areas of the leaf.

- Investigating the need for chlorophyll for photosynthesis:

- We will take a variegated leaf and make a drawing of the leaf, showing the distribution of the green parts that contain chlorophyll, and the white/yellow/pale parts.
- When the variegated leaf is tested for starch on a white tile, some areas will be **blue-black**, while others will be **yellow-brown**.

- Then, we will compare the drawing with our results. It will show that the blue-black areas were the areas containing chlorophyll (thus, starch was present), while the yellow-brown areas were the areas containing no chlorophyll (thus, no starch was present).

- Investigating The Need Of Light For Photosynthesis To Take Place

- Light energy is transferred into chemical energy in the form of glucose

Steps:

- Take a green plant
- Destarch the plant - so all the starch in it is converted into glucose by the enzymes - by placing it in darkness for 48 hours. This ensures that any starch present in the leaves will be used up so the results are not disturbed/affected
- Then, we will cover some part of the leaves with **black paper/aluminium foil** or any other opaque covering, so light doesn't enter that part
- Place the plant back into sunlight so the plant can carry out photosynthesis and produce glucose, which is converted into starch
- Perform the Iodine test on the leaf
- The region which was covered will remain orange-brown upon adding the iodine solution, which indicates that no photosynthesis took place
- The region which was not covered will change to a blue-black colour when iodine solution is added to it, which indicates that photosynthesis took place
- This investigation shows that light is necessary for photosynthesis to take place

- Investigating the Need Of Carbon Dioxide For Photosynthesis To Take Place

- CO_2 is a raw material needed for photosynthesis; it is reduced by hydrogen to make glucose

Steps:

- Destarch 2 potted plants
- Place them in one **bell jar** each. We will have a **control group** and an **experimental group**, so that the results can be compared
- **Experimental group:** Add **sodium hydroxide solution** (other strong bases Like potassium hydroxide or lithium hydroxide can be used as well) in a beaker in the jar. NaOH solution is an absorber of CO_2 ; therefore, it absorbs the carbon dioxide present in the bell jar
- Additionally, **soda lime** will be added on the opening of the bell jar, where the gases enter. Soda lime also helps absorb CO_2 from the air; so, only CO_2 -free air will enter the bell jar
- **Control group:** Add water Instead of NaOH solution in a beaker. No soda lime will be placed on its opening. This allows CO_2 to enter the bell jar
- Now, both plants will be placed in sunlight for a few hours so that photosynthesis can take place
- Test a leaf from each plant for starch using iodine solution

- The leaf from the plant which was supplied CO₂-free air will remain orange-brown after adding iodine solution, showing that photosynthesis has not taken place
- The leaf from the plant placed near water will turn blue-black, showing that photosynthesis has taken place

- Investigating The Effect Of Varying Levels Of Light Intensity, Concentration of Carbon Dioxide And Temperature on the rate of Photosynthesis Using A Submerged Aquatic Plant and Hydrogen Carbonate Indicator Solution:

- Aquatic Plants are the types of plants that can survive submerged under water. They are **adapted** to survive in an aquatic environment
- Suitable species are **pondweed/sea weed** plants such as **hydrilla, cabomba or elodea**
- **Hydrogen carbonate indicator solution**: a pH indicator which can be used to measure the concentration of carbon dioxide over a range of pH values.
- To calculate the rate of reaction, the number of oxygen bubbles can be calculated

- Effect Of Varying Light Intensities On The Rate Of Photosynthesis:

Apparatus design/setup:

- A **beaker** is filled with water and a piece of elodea is placed in it
The elodea is covered with an **inverted funnel** with **wooden bricks** on either end of it, so that water can move
- The inverted funnel is covered with a **test tube** so that gas bubbles can be observed.
As oxygen is less dense than water, it moves up the water and its gas bubbles can be seen
- Light is sourced from a lamp; we will keep the power of light constant, e.g. 60 Watts

Steps:

- Since the effect of **varying light intensity** on the rate of photosynthesis is being investigated, the other limiting factors i.e: temperature and concentration of CO₂ will be kept constant. A **thermometer** can be used to check if temperature is constant throughout the experiment for accurate results. Or, the experiment can be carried out in a **thermostatic room**, where the temperature can be controlled
- To make sure the concentration of CO₂ is constant, we use a hydrogen **carbonate indicator solution**. The purpose of this solution is to help us determine the concentration of the CO₂. It will change colours depending upon the concentration
- The lamp connected will give constant light of power 60 Watts for the experiment. Only the distance of the lamp from the aquatic plant will be changed
- A ruler or measuring tape can be used to measure the distance of the light source from the aquatic plant
- The lamp will first be kept only 0.5 m away from the elodea plant and observe the number of oxygen bubbles formed, which will indicate that photosynthesis is taking place
- This will be repeated at a distance of 1 m, then 1.5 m, and lastly, 2 m
- At each interval of distance, the number of oxygen bubbles formed will be calculated

- Effect Of Changing The Temperature On The Rate Of Photosynthesis:

Apparatus design/setup:

- A **beaker** is filled with water and a piece of elodea is placed in it
- The elodea is covered with an **inverted funnel** with **wooden bricks** on either side of it, so that water can move
- The inverted funnel is covered with a **test tube** so that gas bubbles can be observed. As oxygen is less dense than water, it moves up the water, and its gas bubbles can be seen
- Light is sourced from a lamp; we will keep the power of light constant e.g. 60 Watts
- A **thermometer** is used to measure the temperature
- The beaker is heated using an electric **heater** to ensure an even temperature throughout the medium

Steps:

- We are investigating the effect of **changing temperature**, so, we will keep the other limiting factors, **light intensity and concentration of CO₂**, constant throughout the experiment
- **Hydrogen carbonate indicator solution** can be used to make sure the concentration of CO₂ is constant, because it will change colours depending upon its concentration
- To keep the light intensity constant, we will use a lamp with a constant power of e.g. 60 Watts, and we will keep it at a distance of 0.5m away from the elodea plant throughout the experiment
- We will now perform the experiment. Firstly, we'll keep the temperature at 20C and observe the number of oxygen bubbles formed. Then the temperature will be increased to 30C, then 40C, and lastly, 60C.
- We will observe the number of oxygen bubbles formed per unit time in the inverted test tube, floating up through the inverted funnel

- Effect Of Changing The Concentration Of Carbon Dioxide On The Rate Of Photosynthesis:

Apparatus design/setup:

- A **beaker** is filled with water and a piece of elodea is placed in it
- The elodea is covered with an **inverted funnel** with **wooden bricks** on either end of it, so that water can move
- The inverted funnel is covered with a **test tube** so that gas bubbles can be observed. As oxygen is less dense than water it moves up the water, and its gas bubbles can be seen
- Light is sourced from a lamp; we will keep the power of light constant e.g. 60 Watts
- A **thermometer** is used to ensure that the temperature remains constant throughout the experiment
- **Hydrogen carbonate indicator solutions (HCO₃)** of different concentrations will be dissolved in the beaker

Steps:

- We will keep the light intensity and temperature constant

- Hydrogen carbonate solution will be used
- We will repeat the experiment 10 times, each time with a different concentration of HCO_3 dissolved in the beaker
- The concentration of HCO_3 is proportional to the concentration of carbon dioxide present in the beaker
- Concentrations from $0.01 - 0.1 \text{ mol/dm}^3$ of HCO_3 will be used for the experiment
- Measure the rate of bubbles coming out and calculate their number. Record the data in a graph.

A Note from Mojza

These notes for Biology (5090/0610) have been prepared by Team Mojza, covering the content for GCE O levels and IGCSE 2023-25 syllabus. The content of these notes has been prepared with utmost care. We apologise for any issues overlooked; factual, grammatical or otherwise. We hope that you benefit from these and find them useful towards achieving your goals for your Cambridge examinations.

If you find any issues within these notes or have any feedback, please contact us at support@mojza.org.

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